FAA Pavement Design

Flexible Pavement FAARFIELD Design Example

Presented to: FAA Southwest Region
2008 Partnership Conference

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Airport Engineering Division

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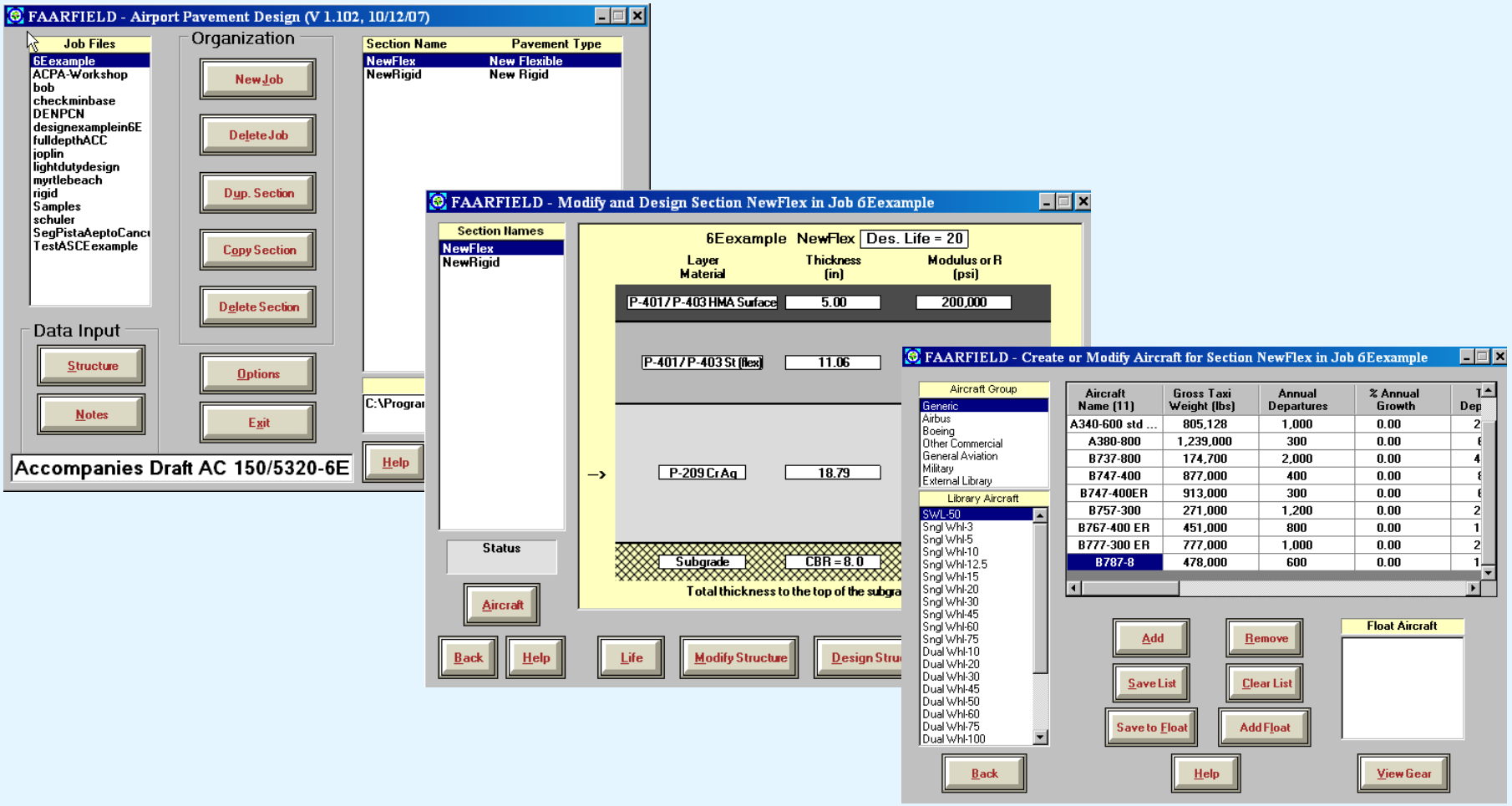
Federal Aviation Administration

FAARFIELD Flexible Pavement Design



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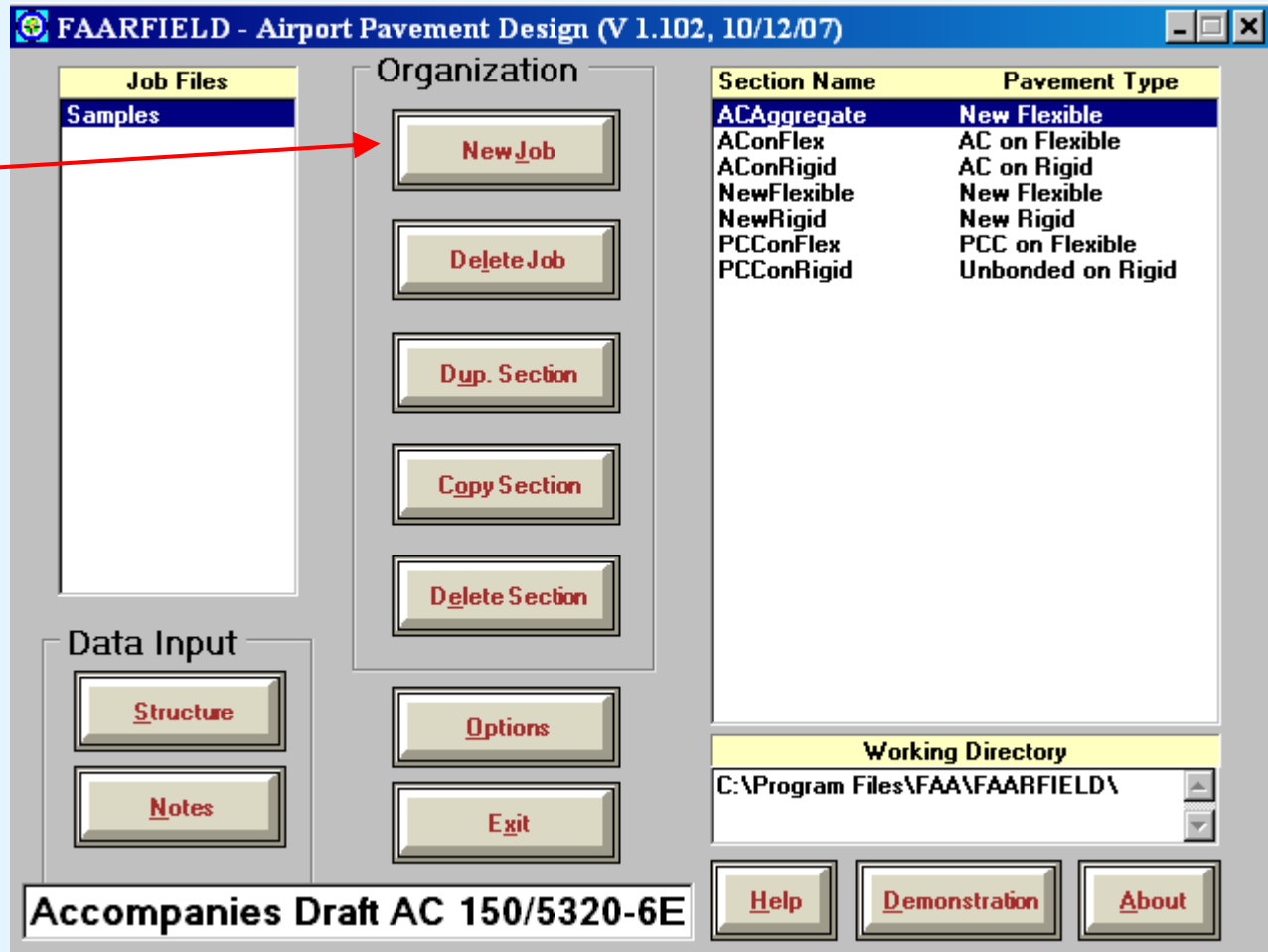
Starting Screen – No Job Files Created

Click on “New Job”



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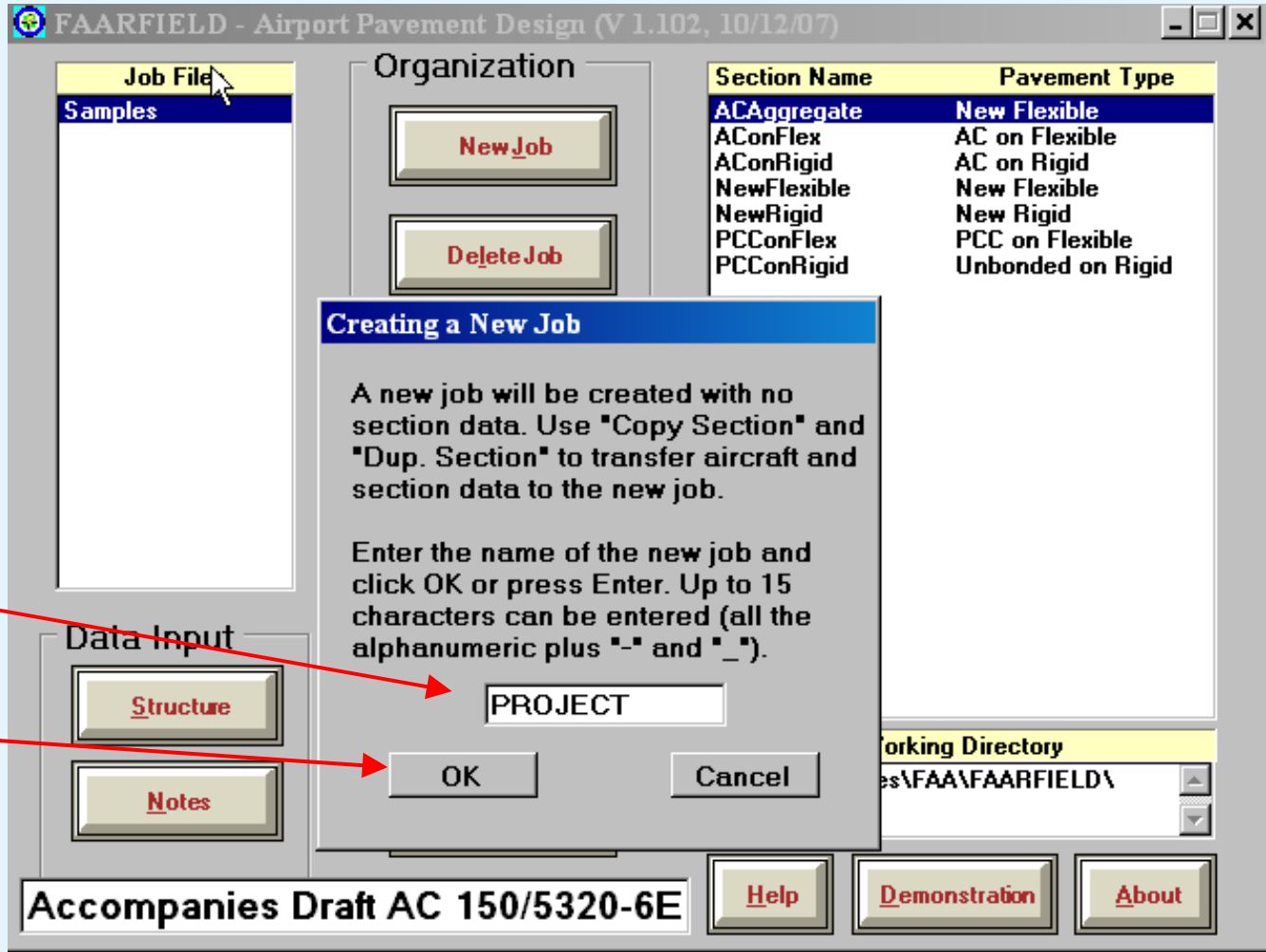
Creating / Naming a Job File



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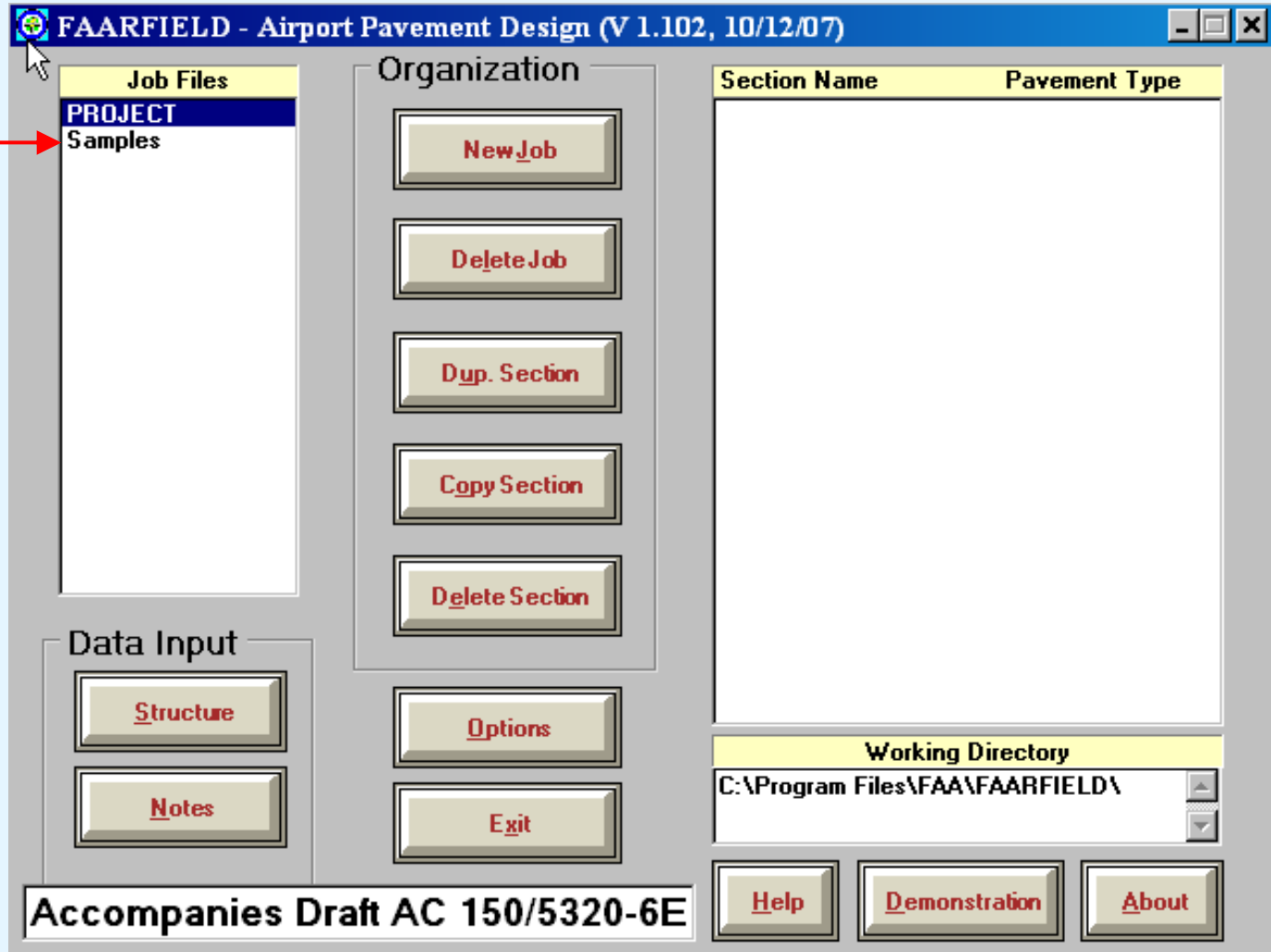
Copy Basic Section/Pavement Type from Samples

Click on “samples”



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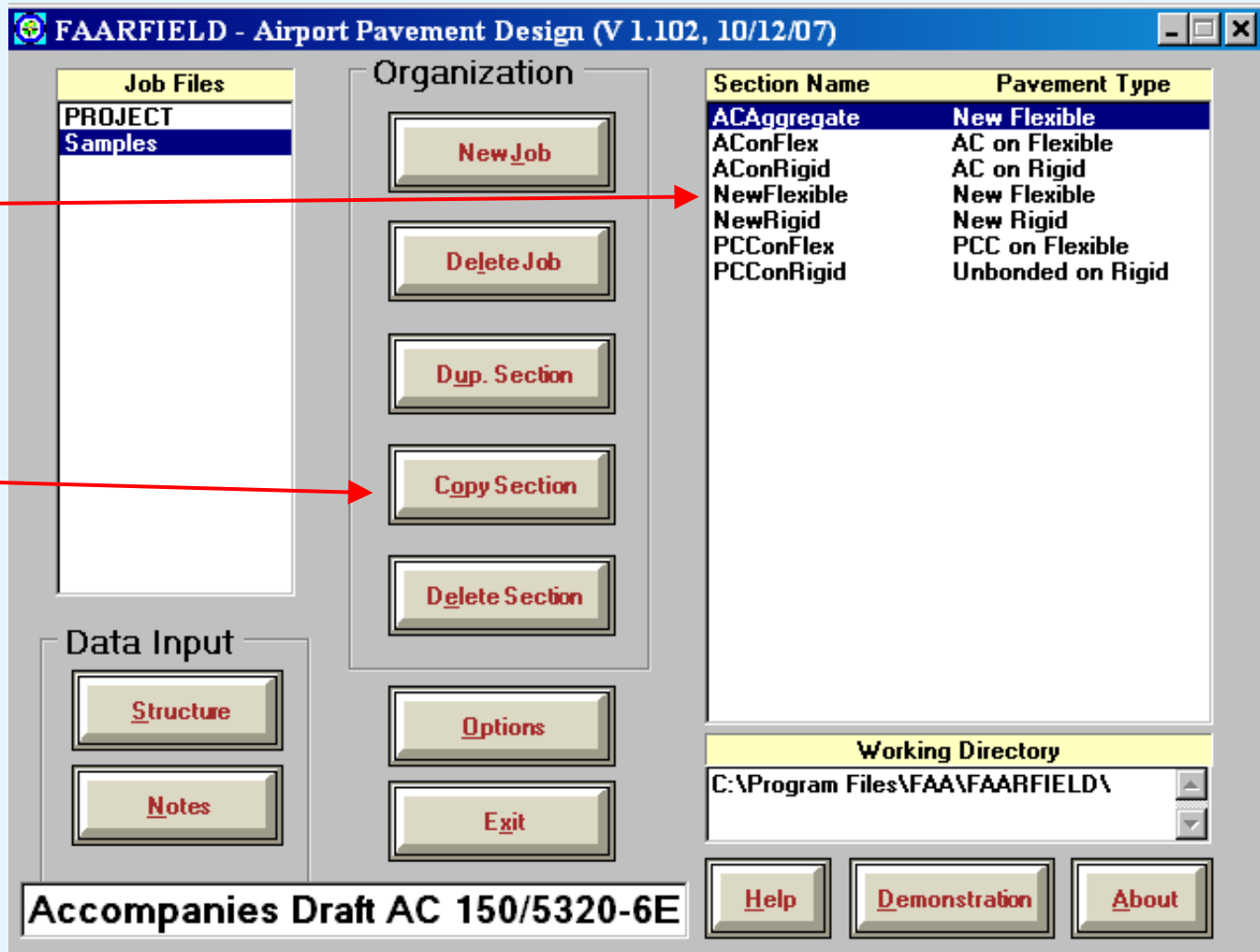
Copy Basic Section/Pavement Type from Samples

Default Basic Pavement Sections

Click on "Copy Section"



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7 Basic Starting Structures in LEDFAA

Section Name	Pavement Type
ACAggregate	New flexible on Aggregate base
AConFlex	Asphalt overlay on Flexible pavement
AConRigid	Asphalt overlay on Rigid pavement
NewFlexible	New Flexible on stabilized base
NewRigid	New Rigid on stabilized base
PCConFlex	PCC overlay on flexible
PCConRigid	Unbonded PCC on rigid

Be sure to select the pavement type that most correctly represents your pavement needs

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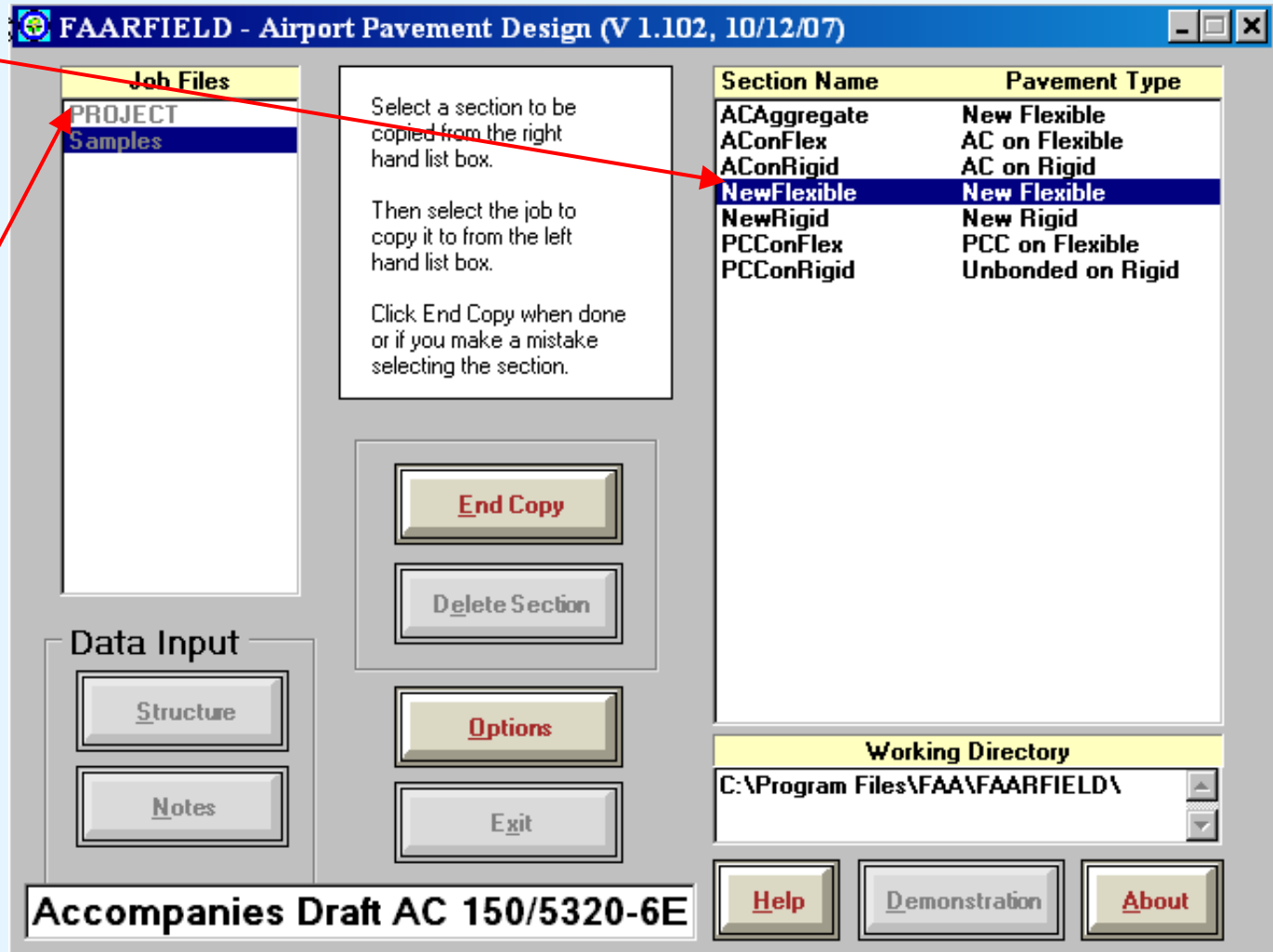
Copy a Typical Pavement Section

Click on desired pavement section

Then click on the project where the section will be saved



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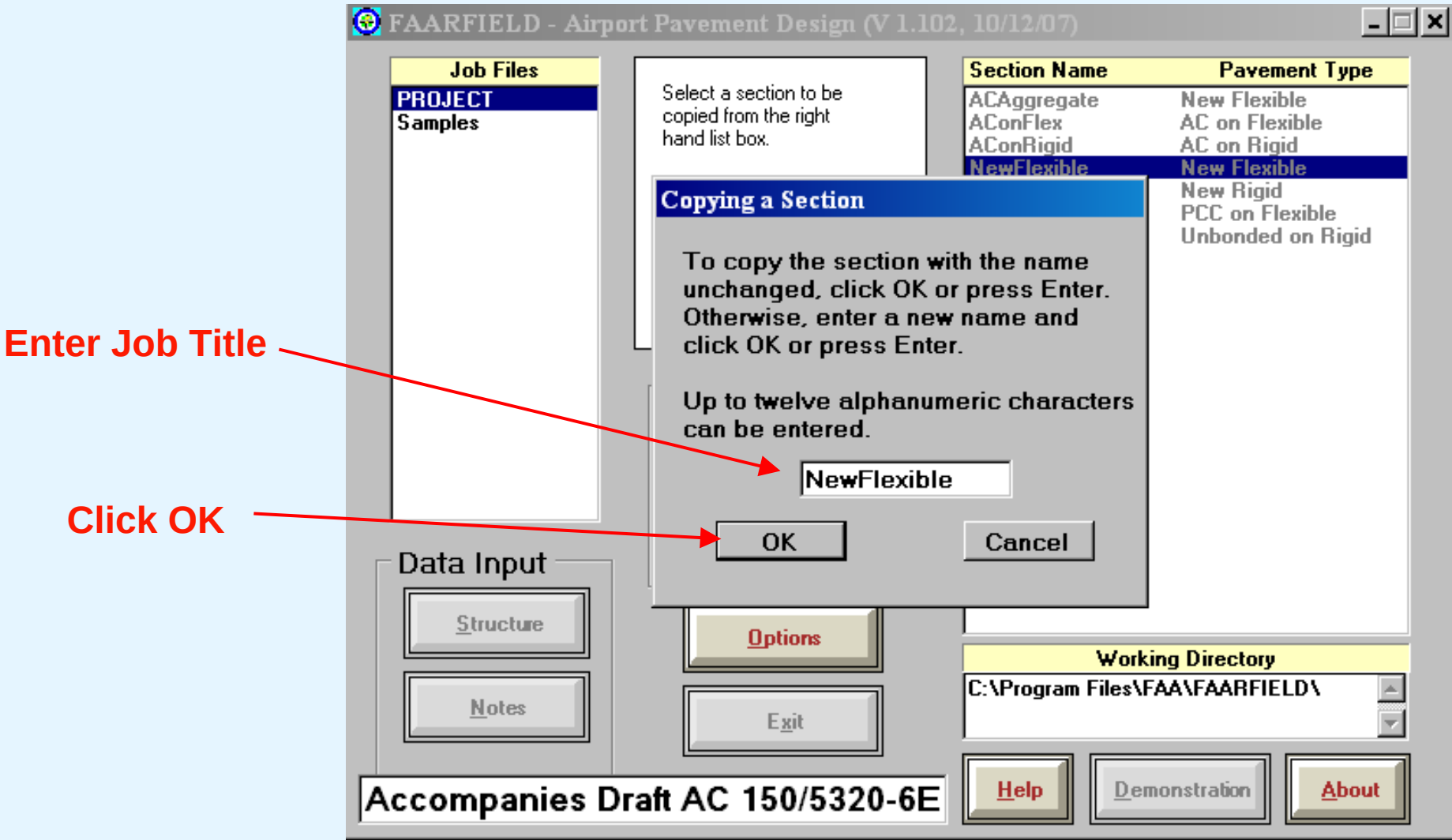
Create a New Job Title



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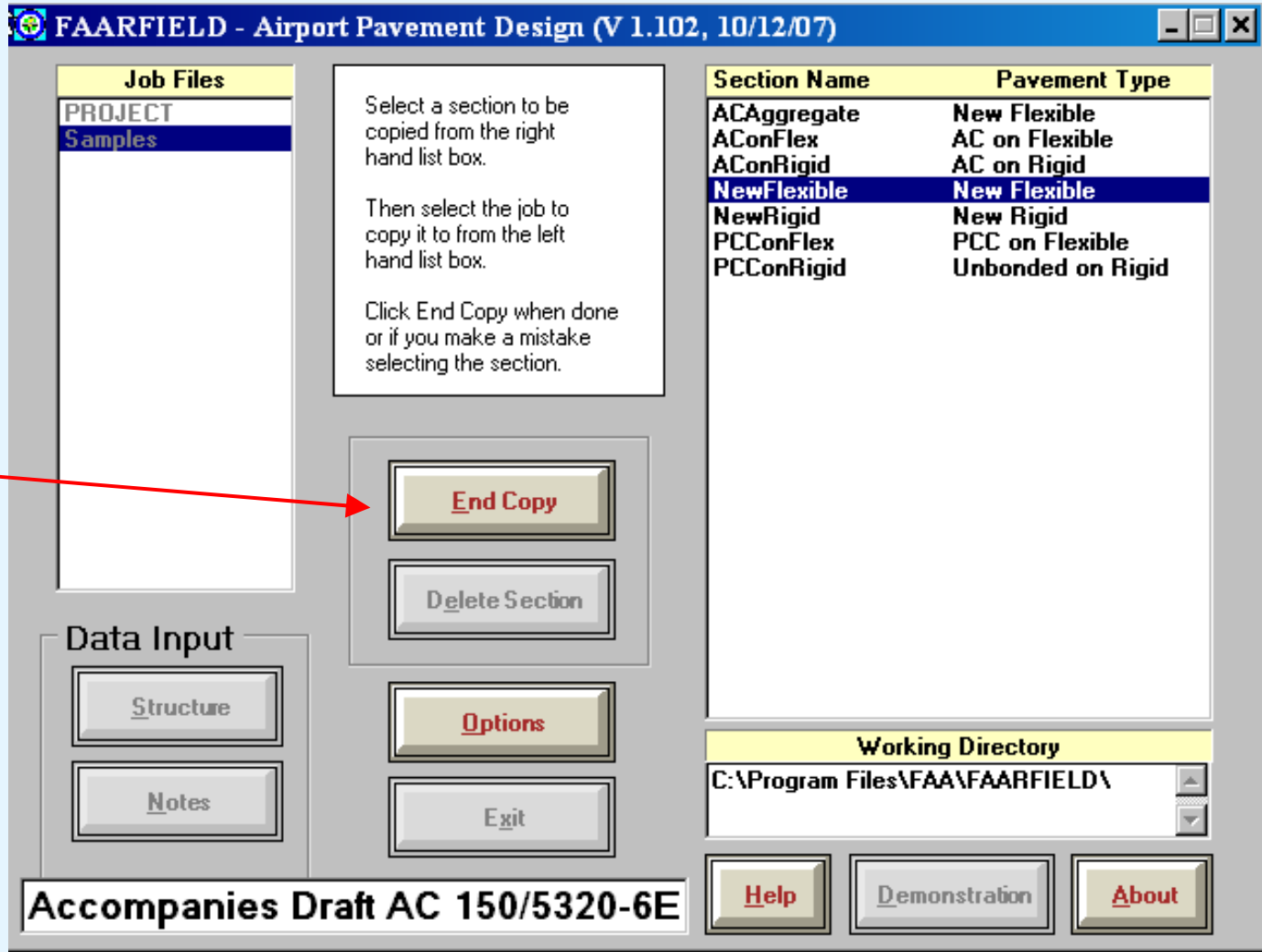
Create a New Job Title

Click “End Copy”



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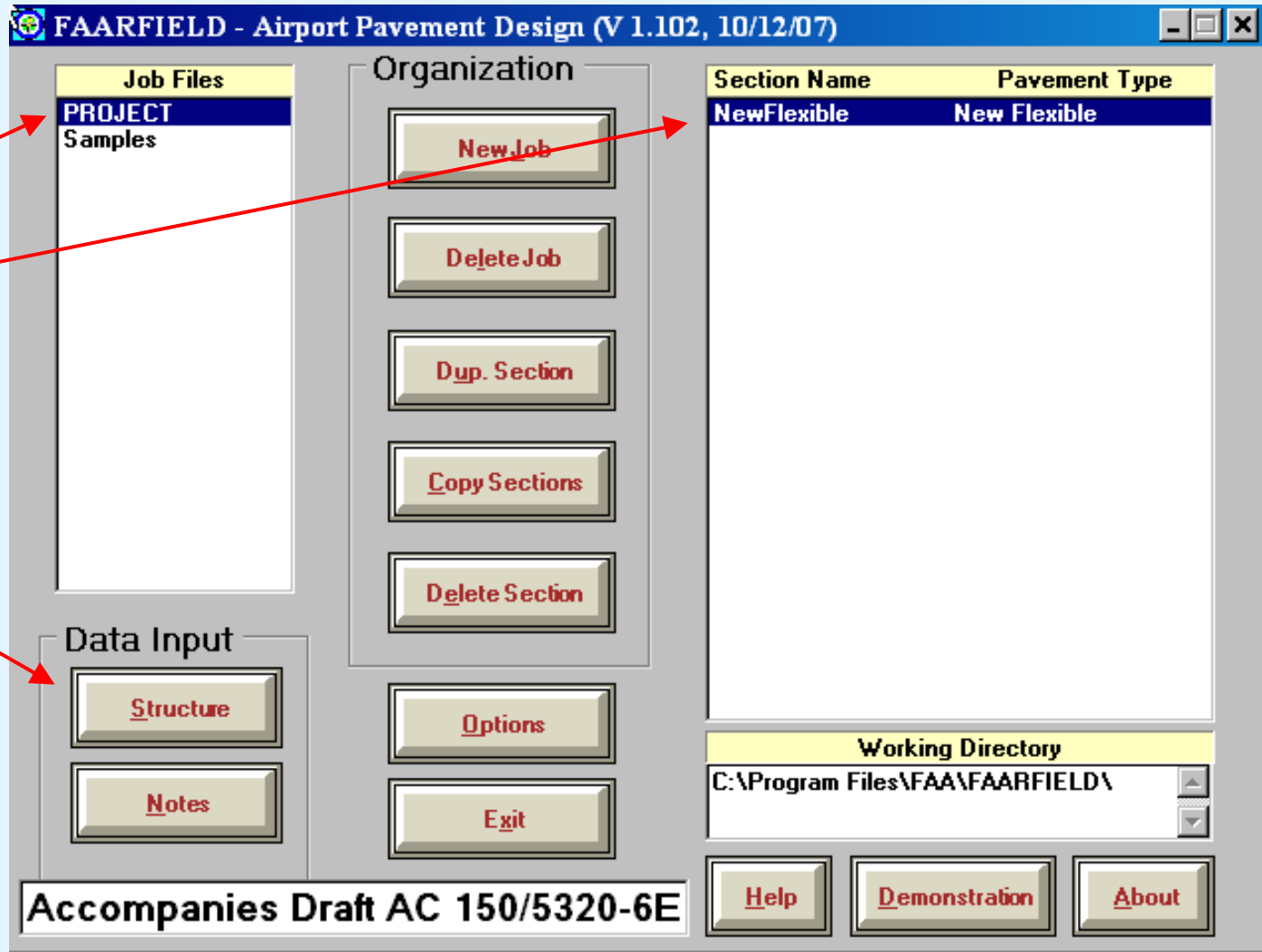
Working With a Design Structure

Select the job and then select the section you want to analyze

Click on “Structure” To open the file



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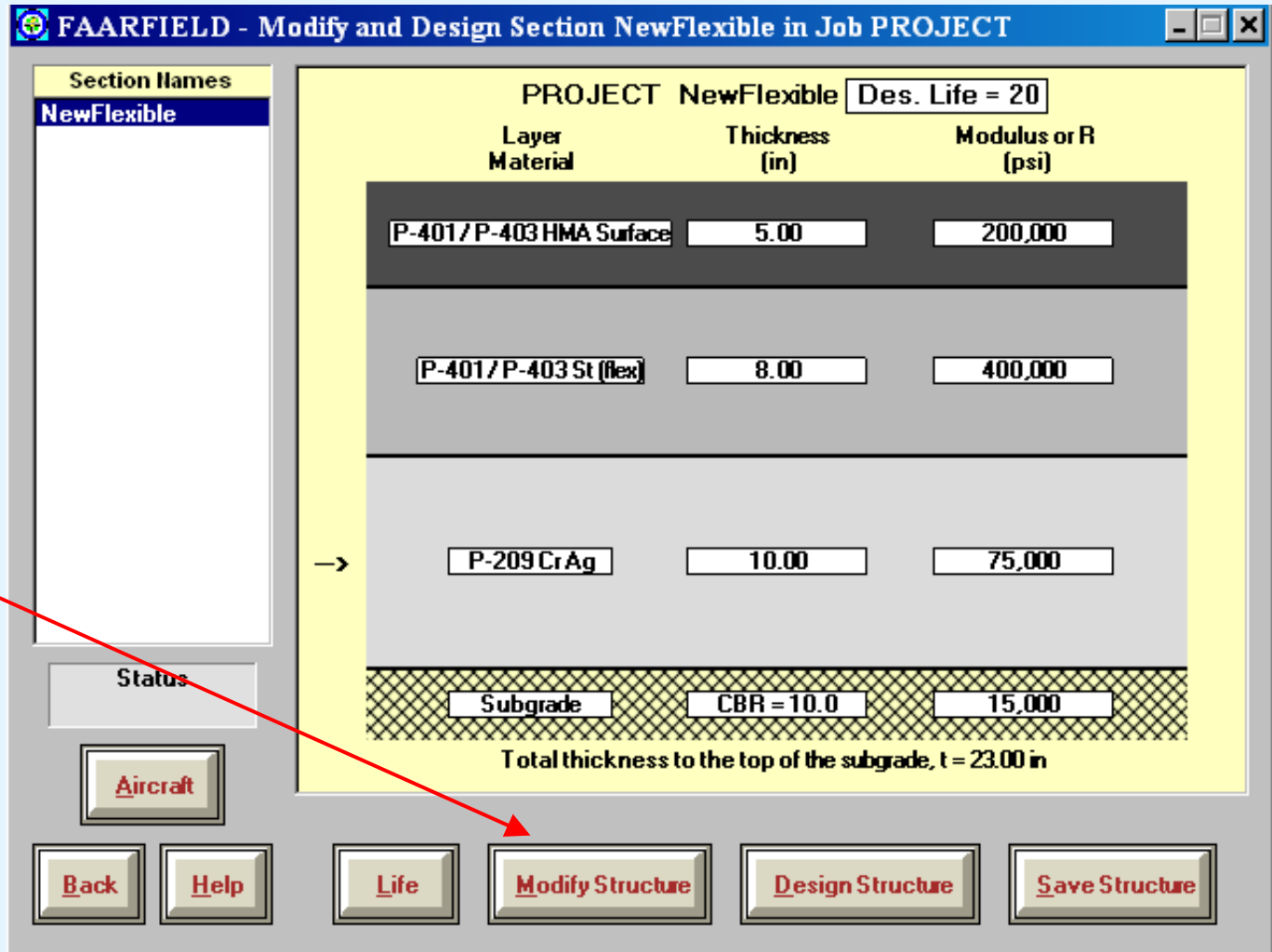
Working With a Pavement Section

The selected sample pavement will appear

The structure may be modified if desired



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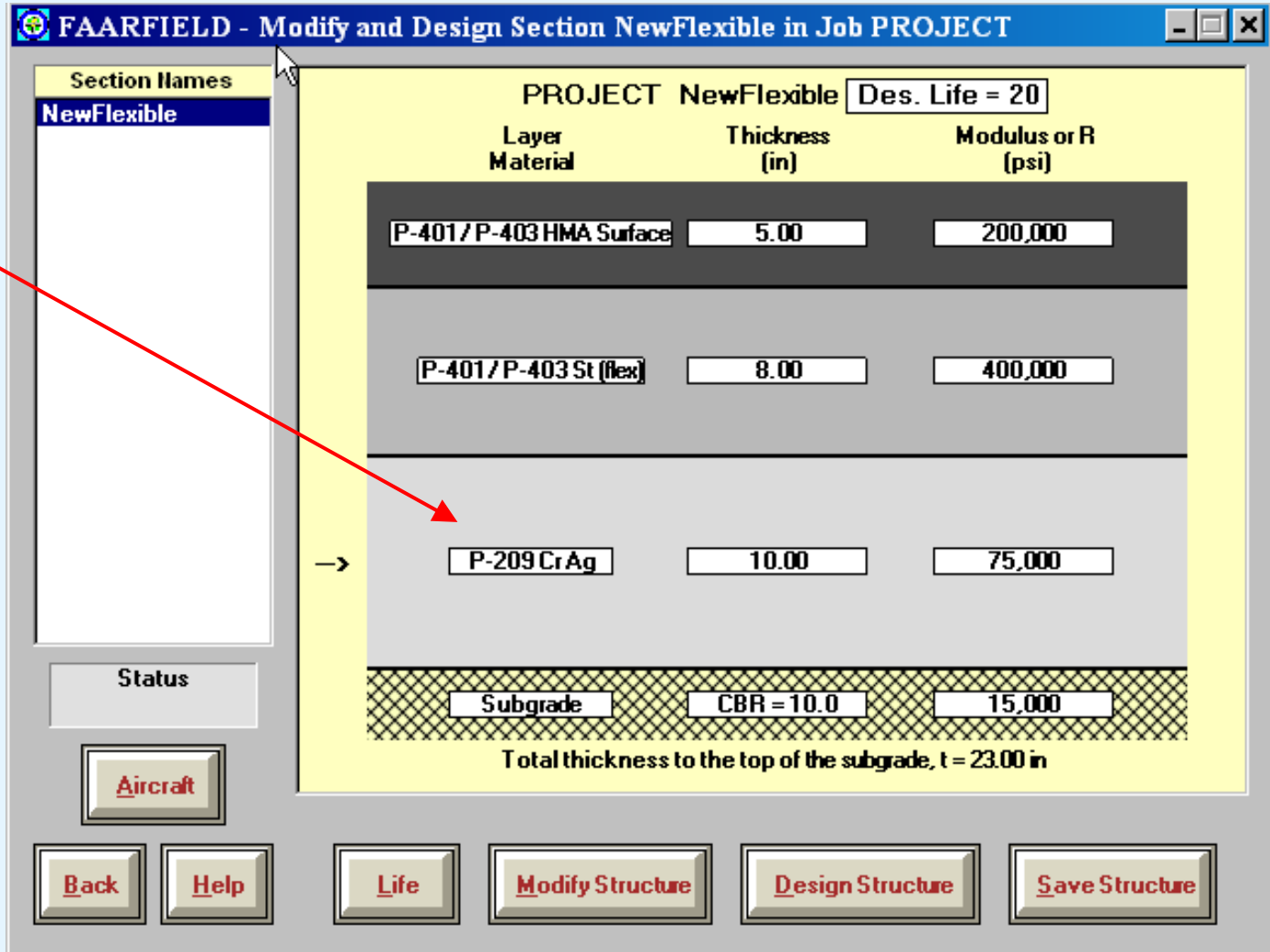
Modifying a Pavement Section

Click on the box around the layer material you want to modify



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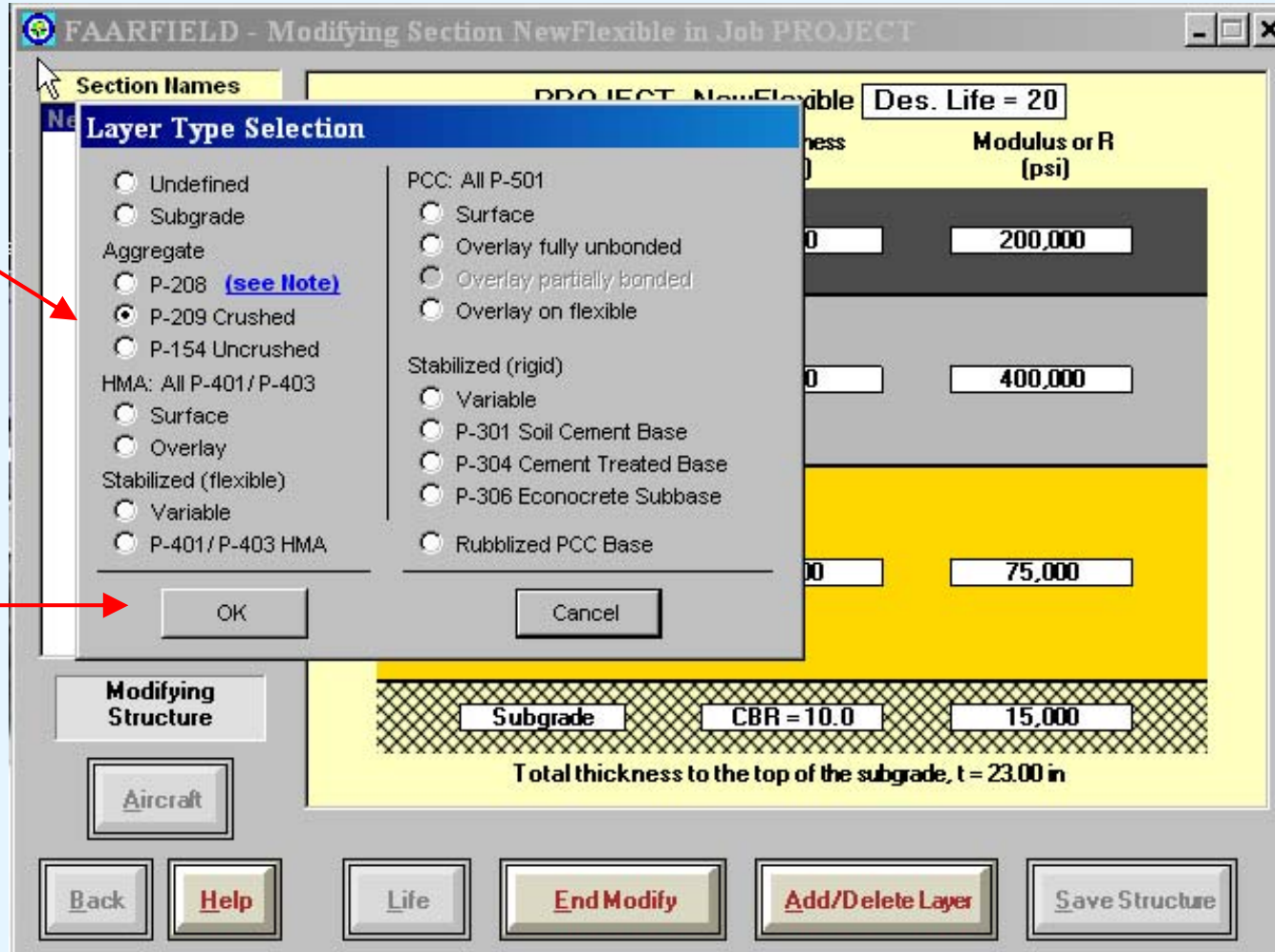
Modifying a Pavement Section

Select the layer type you want to include in your pavement section

No modification for this example

Click OK

Cancel for this example



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Layer Placement Restrictions

There are restriction on placement of certain pavement layers.

e.g. You can not place an “overlay” below a “surface” course.

Other restrictions prevent or cause changes in the pavement type (flexible or rigid)

e.g. Changing a surface asphalt layer to a rigid layer will change the pavement type.

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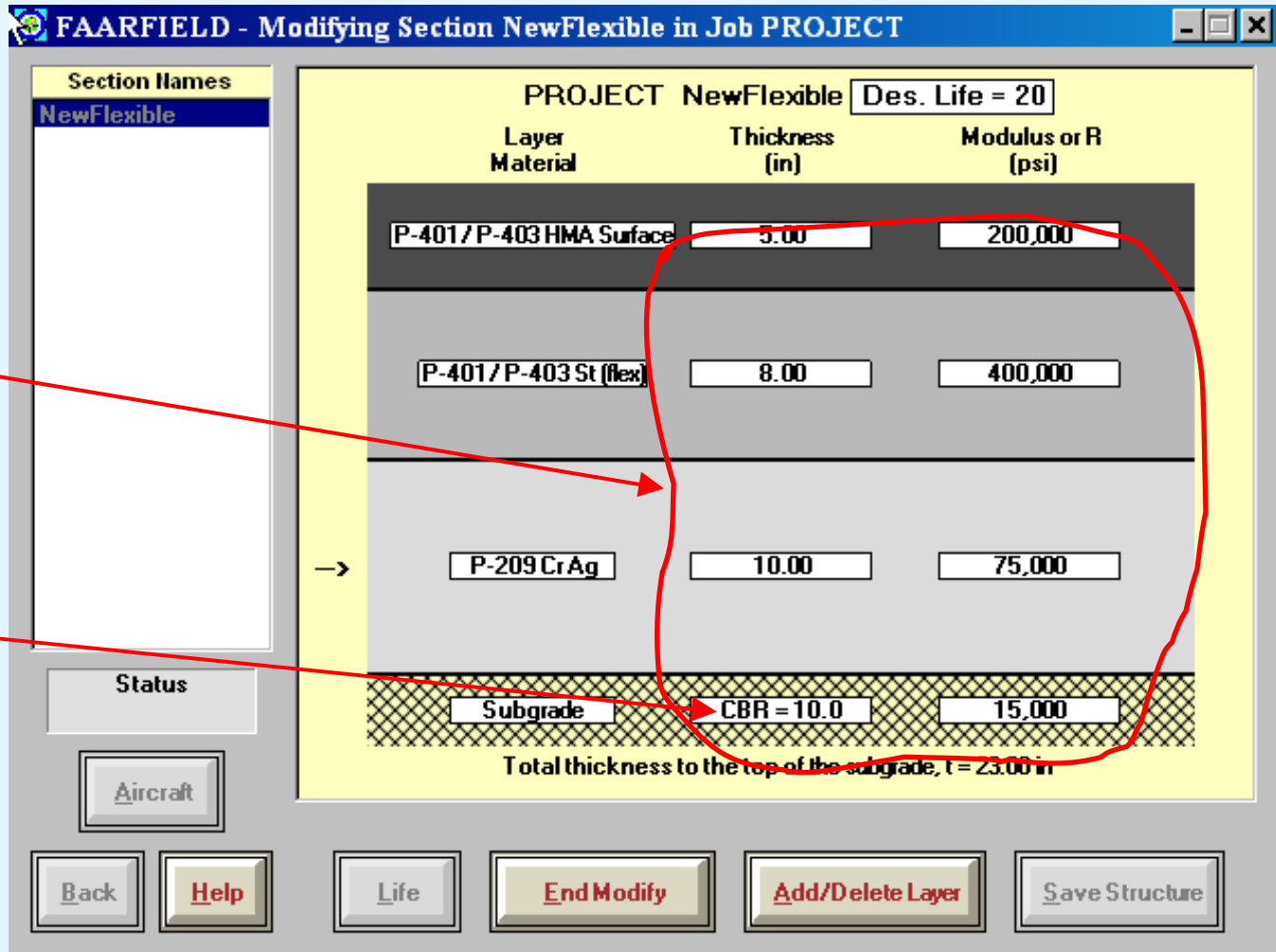
Modifying a Pavement Section

Click on a property to modify any of the layer properties

Modify the subgrade CBR for this example



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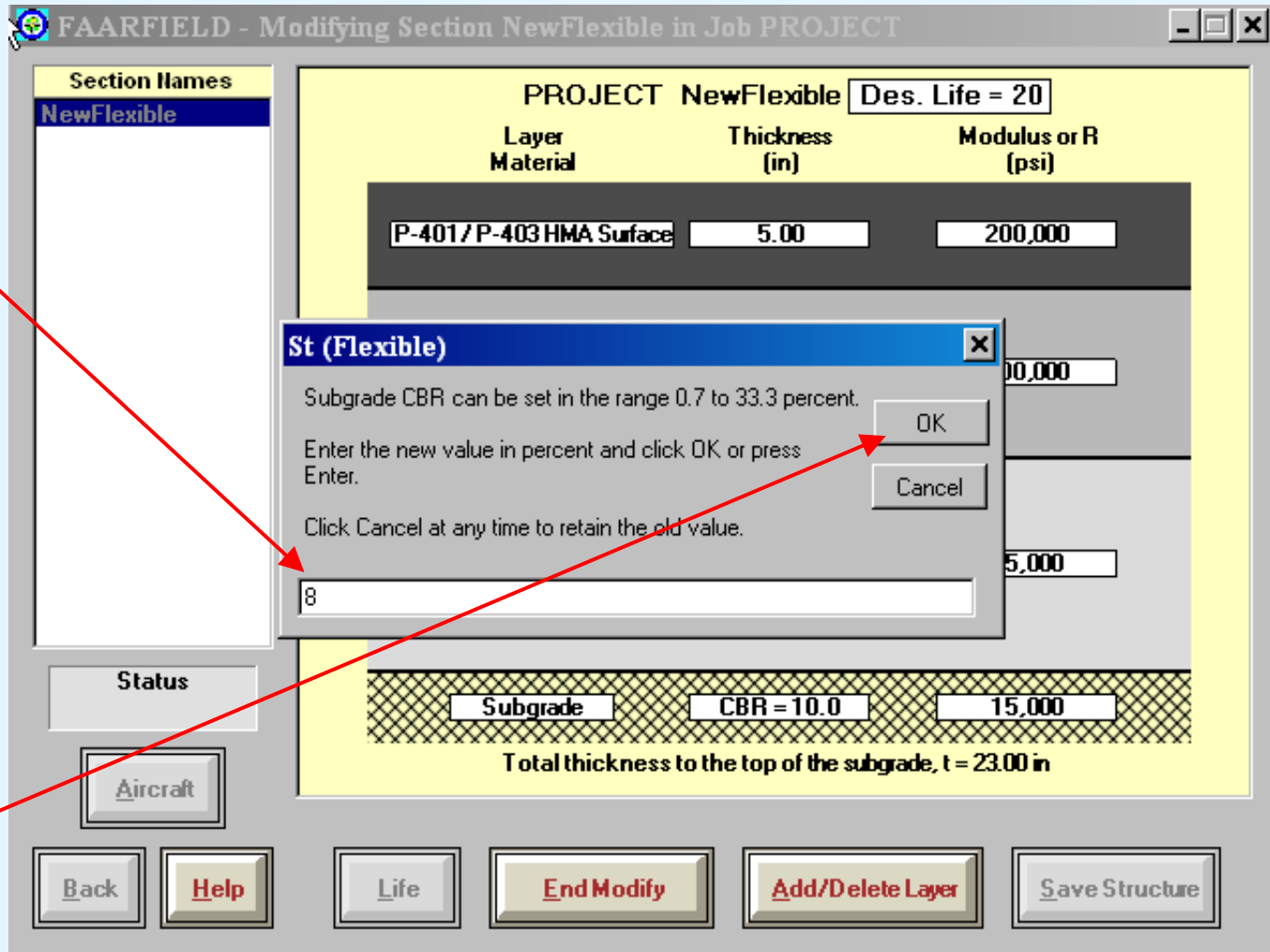
Modifying a Pavement Section

Enter the new value for the material property
***** some materials will have limits on property values***

use 8 for this example

Click OK



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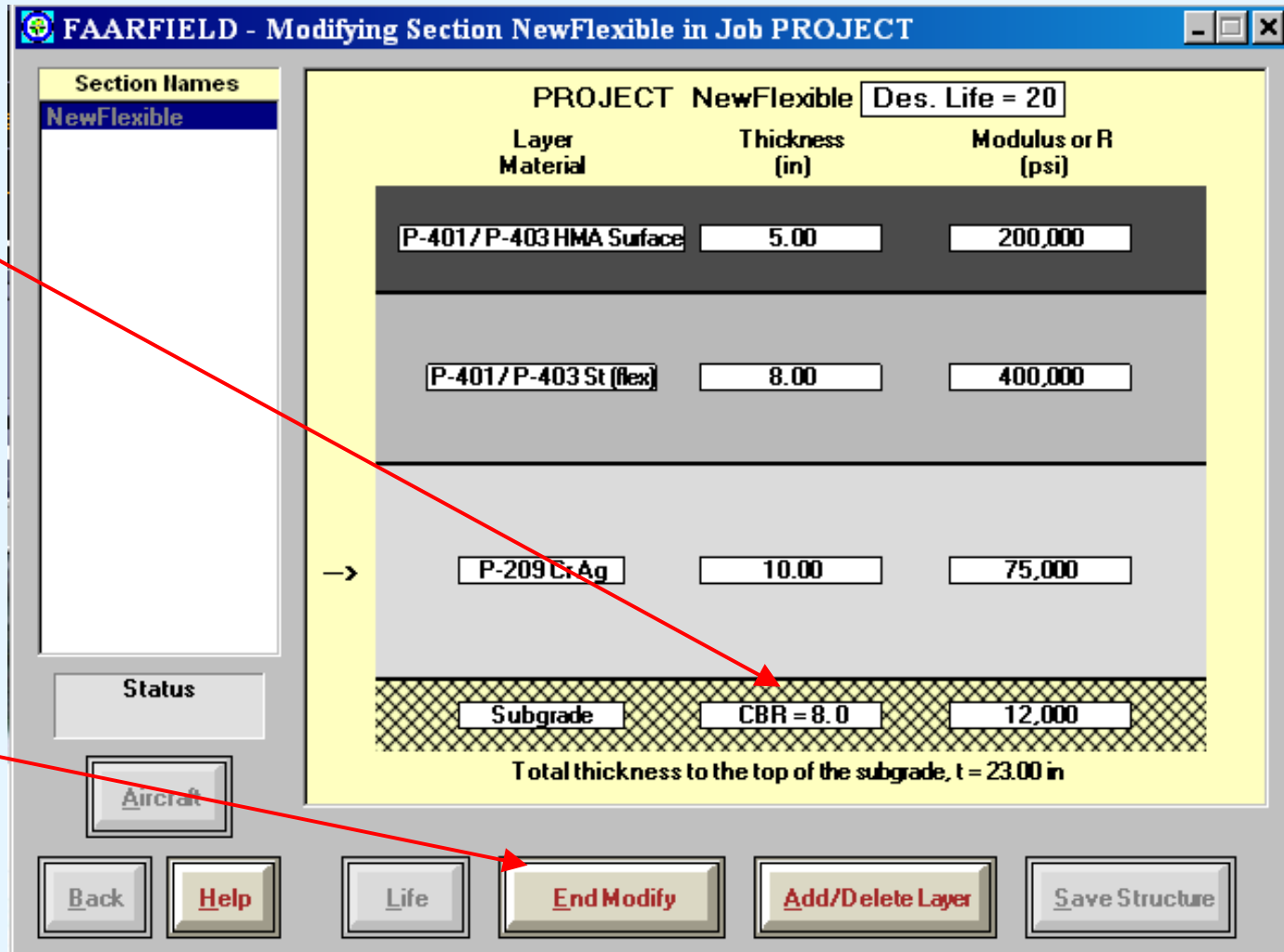
Modifying a Pavement Section

New values appear in the structure window

Click End Modify



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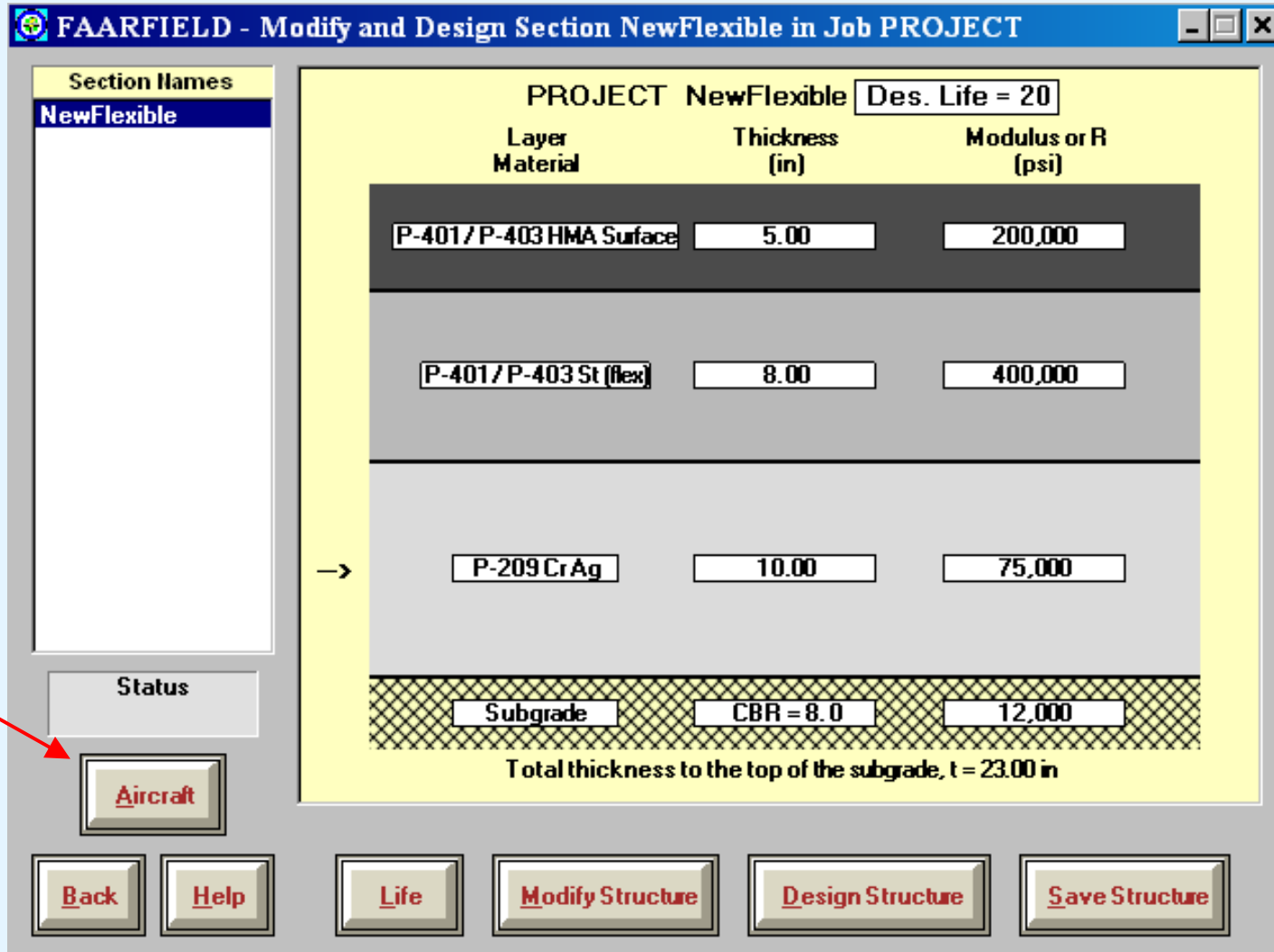
Enter Traffic Mixture

Click on “Aircraft”
To enter traffic mix



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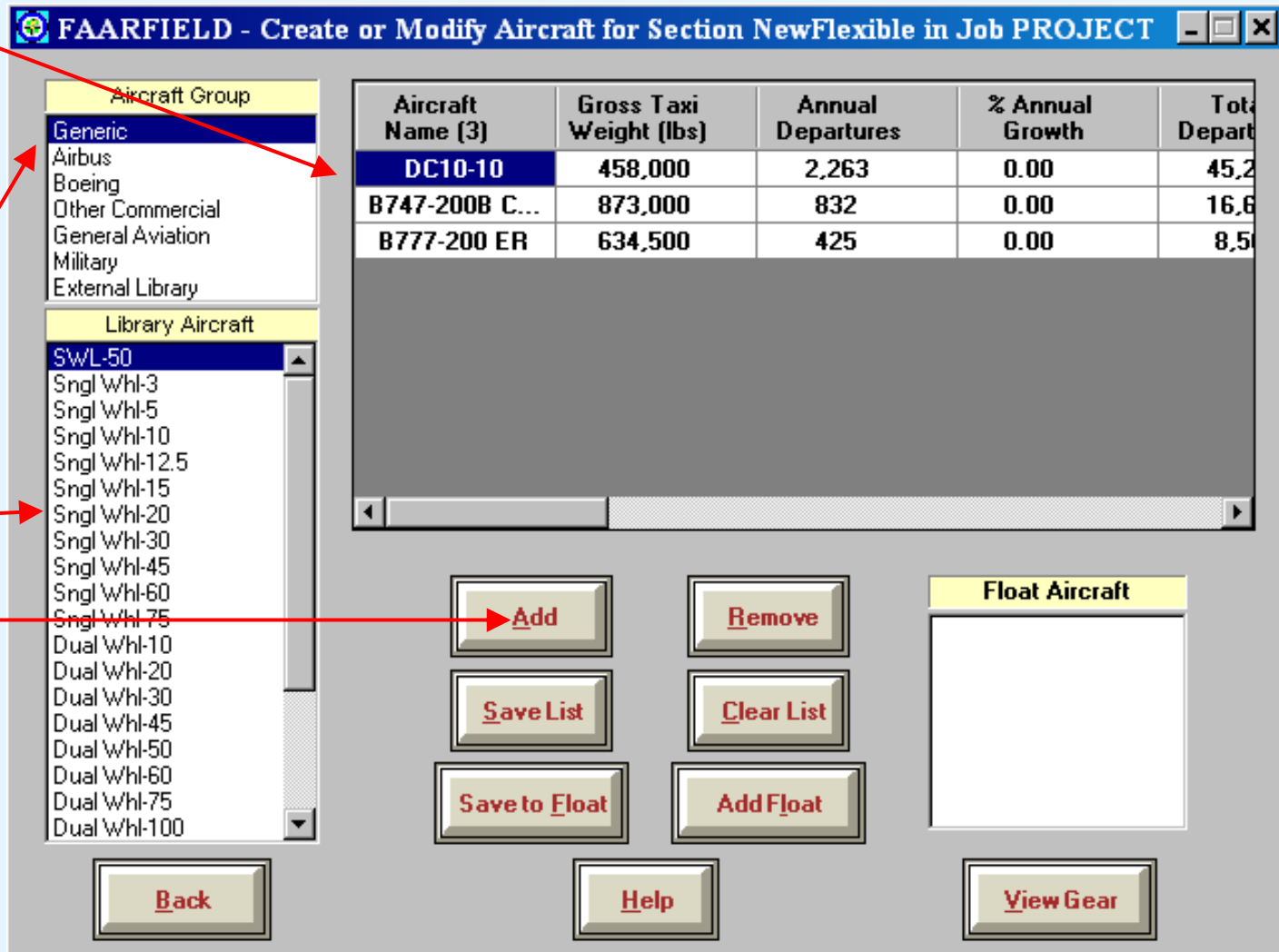
Enter Traffic Mixture

You may want to clear any existing airplanes

Click on the airplane group desired.

Then select the desired airplane and click “Add”

Repeat for complete traffic mixture



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Traffic Mix for this example

No.	Name	Gross Weight, lb	Annual Departures	Annual Growth, %
1	A320-100	150,796	600	0.00
2	A340-600 std	805,128	1,000	0.00
3	A340-600 std Belly	805,128	1,000	0.00
4	A380-800	1,239,000	300	0.00
5	B737-800	174,700	2,000	0.00
6	B747-400	877,000	400	0.00
7	B747-400ER	913,000	300	0.00
8	B757-300	271,000	1,200	0.00
9	B767-400 ER	451,000	800	0.00
10	B777-300 ER	777,000	1,000	0.00
11	B787-8	478,000	600	0.00

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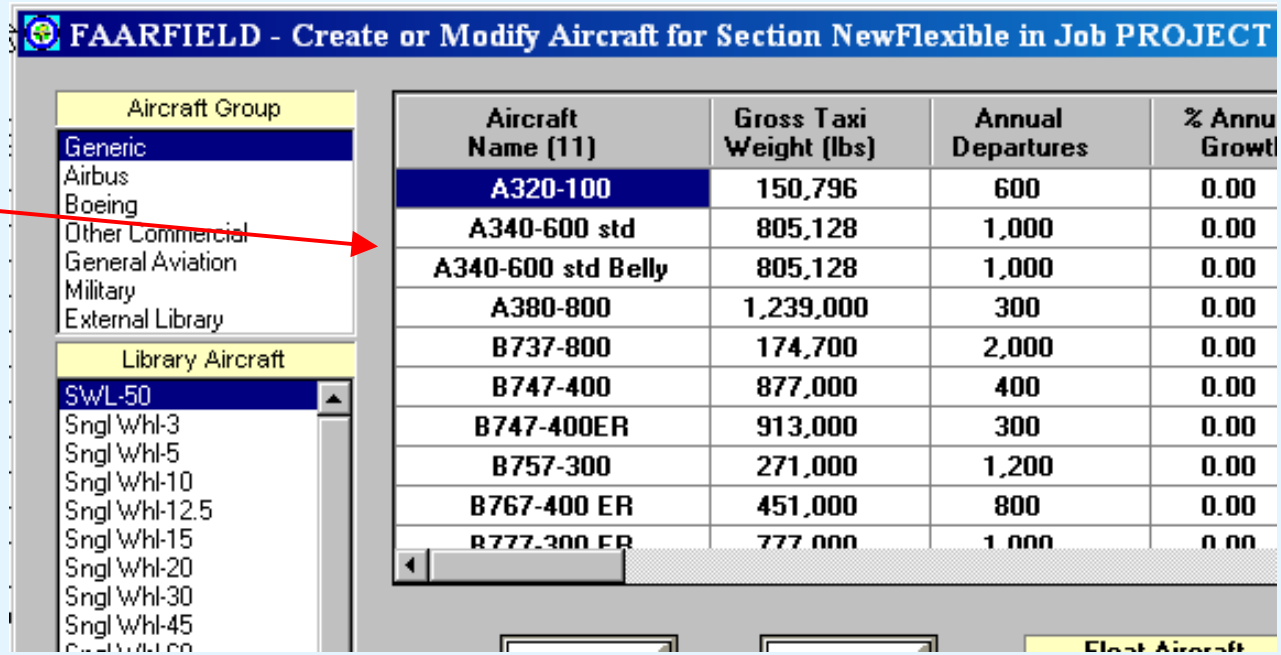
Enter Traffic Mixture

Certain airplanes may appear in the list twice. This is to address the presence of wing gears and belly gears

FAARFIELD treats these as two airplanes however the weight and departures are interlocked



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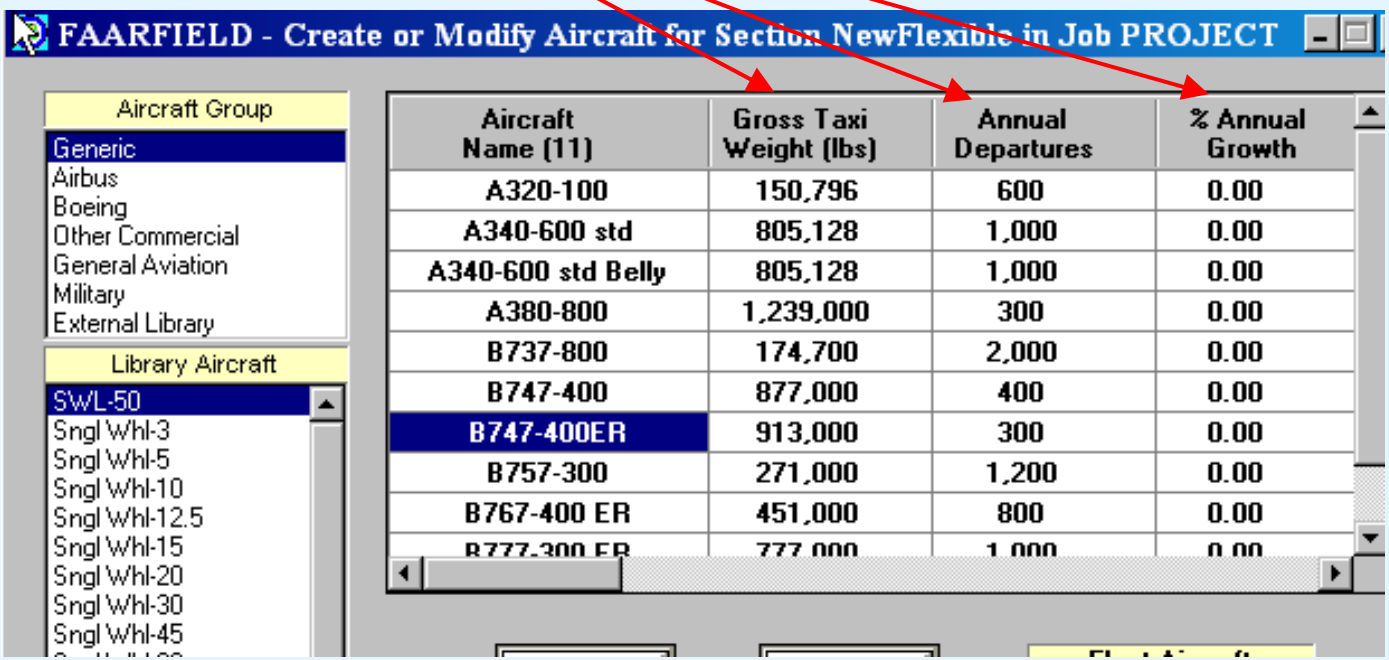
Adjusting Airplane Information

Gross Taxi Weight, Annual Departures and % Annual Growth may be modified



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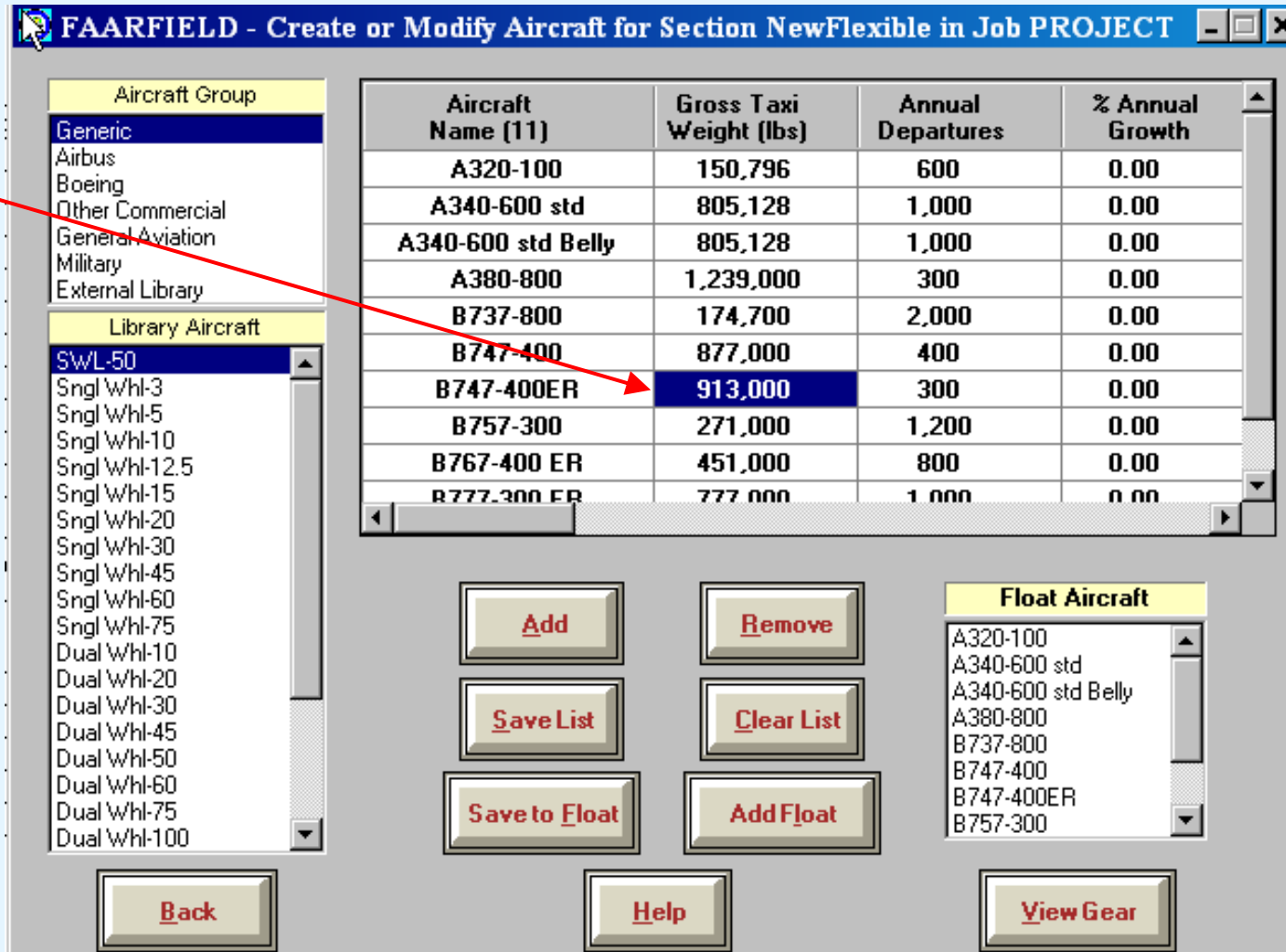
Adjusting Airplane Information – Gross Weight

Click on the airplane gross weight to change the weight



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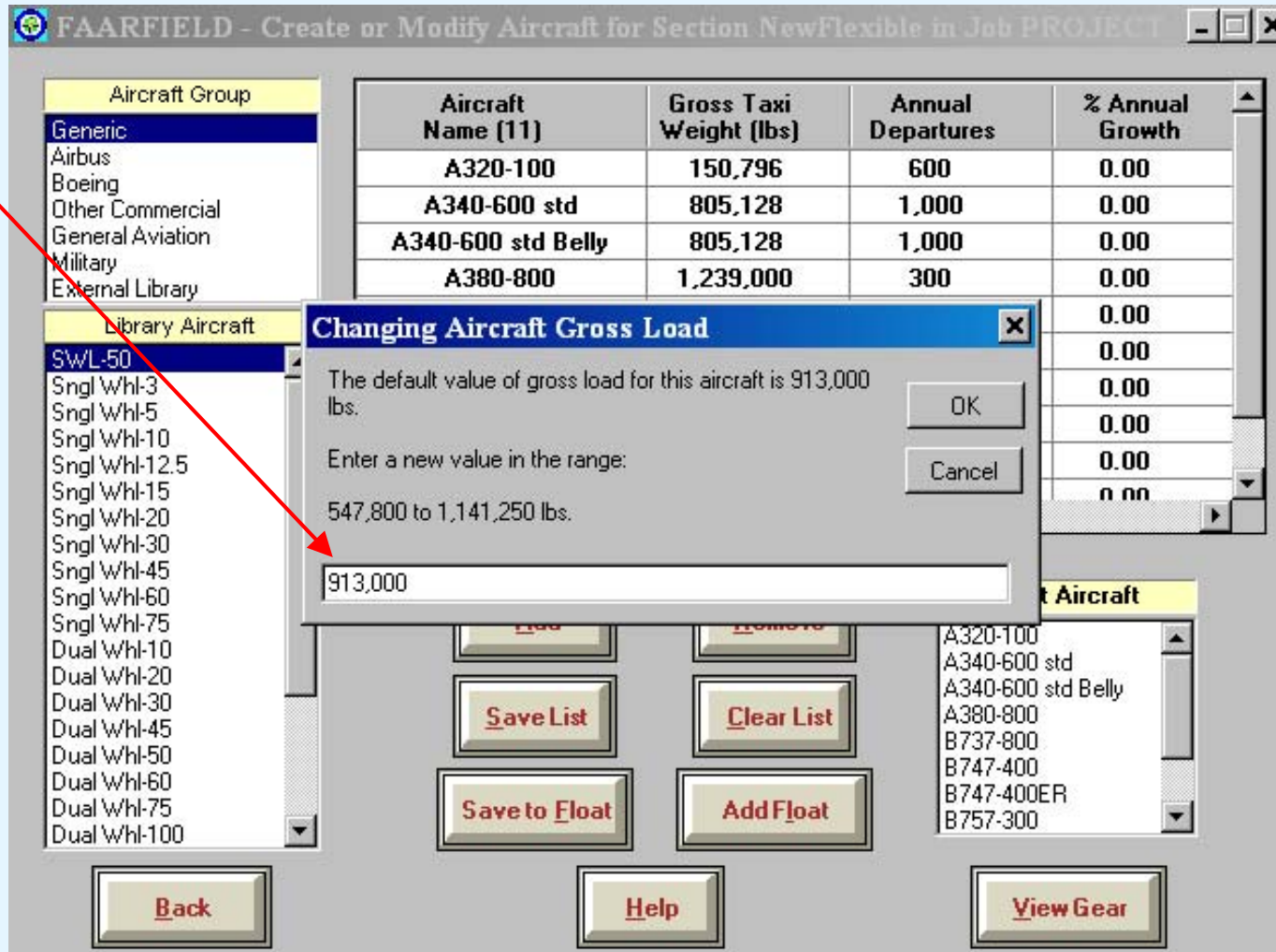
Adjusting Airplane Information – Gross Weight

Enter the new weight and click OK



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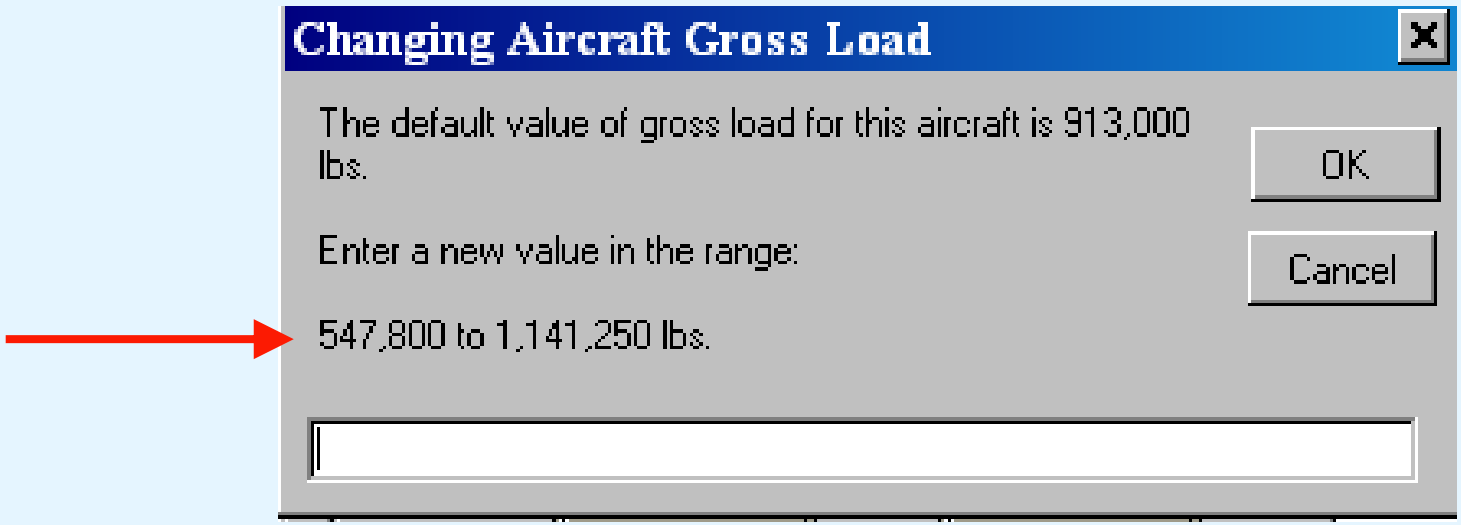
Airplane Information – Gross Weight Limitations

There are limitations on changes to airplane gross weights.

A range is provided for each airplane which represents reasonable weights for the airplane



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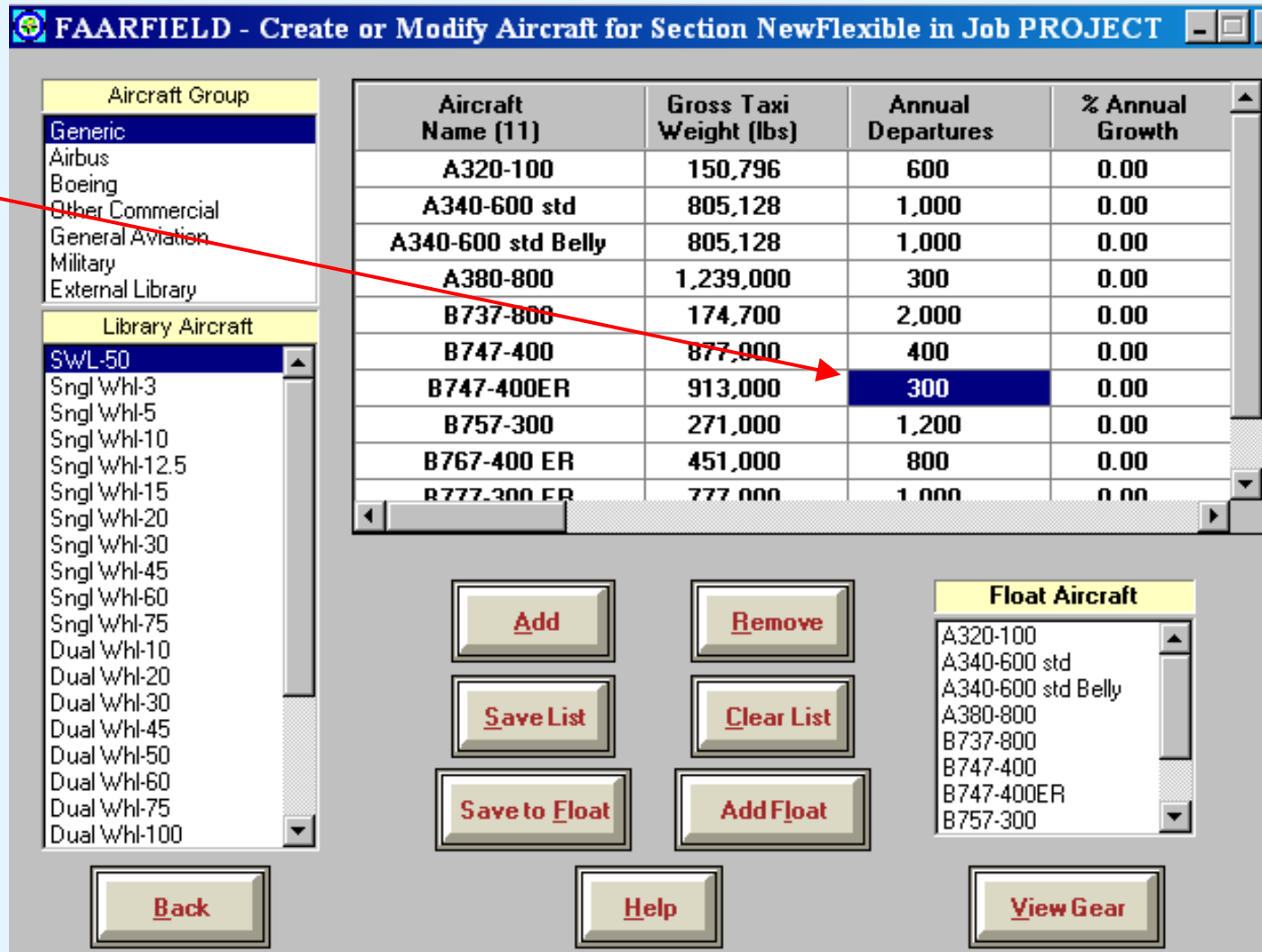
Adjusting Airplane Information – Annual Departures

Click on "Annual Departures" to change departures for an airplane



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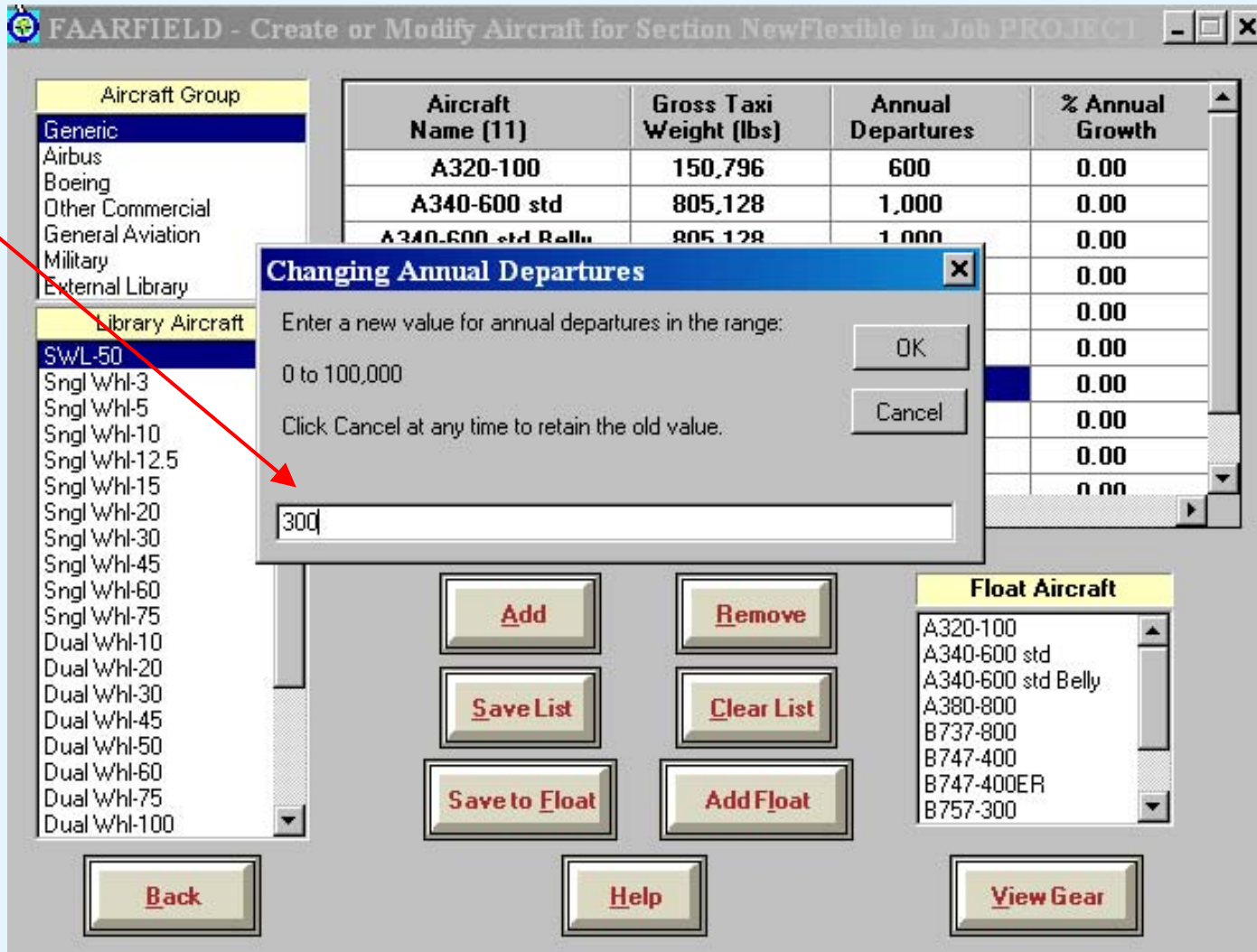
Adjusting Airplane Information – Annual Departures

Enter the annual departures of the airplane
Click OK



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Annual Departures in FAARFIELD

- Annual departures has the same meaning as the previous design procedure.
- Arrivals are ignored.
- For design purposes FAARFIELD uses the total annual departures, adjusted for growth, multiplied by the total design period in years

  e.g. 1200 annual departures X 20 years = 24,000 departures

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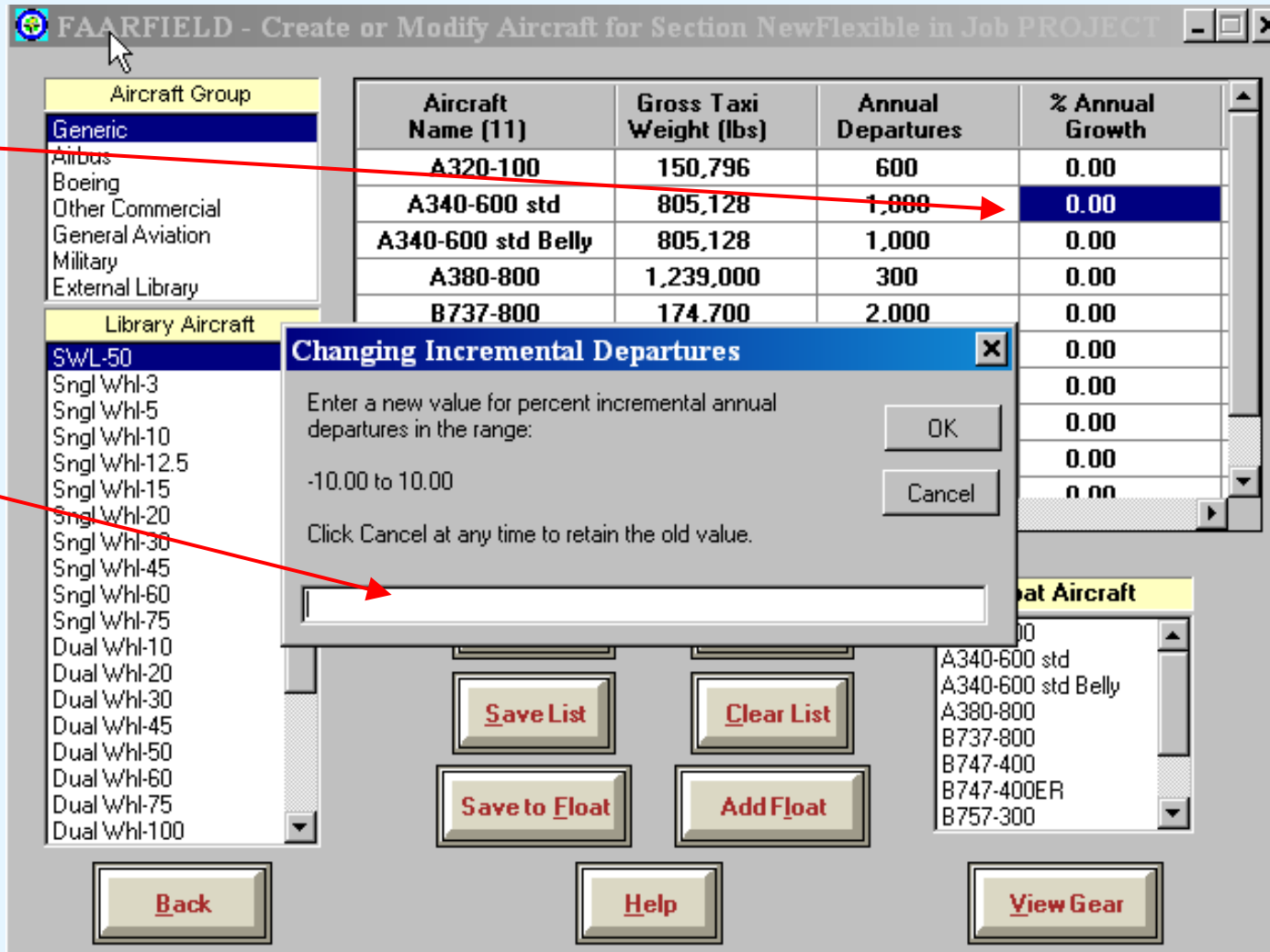
Adjusting Airplane Information –

% Annual Growth of Annual Departures

Click on the annual growth value to bring up the pop-up box.

Enter the percent annual growth and click OK



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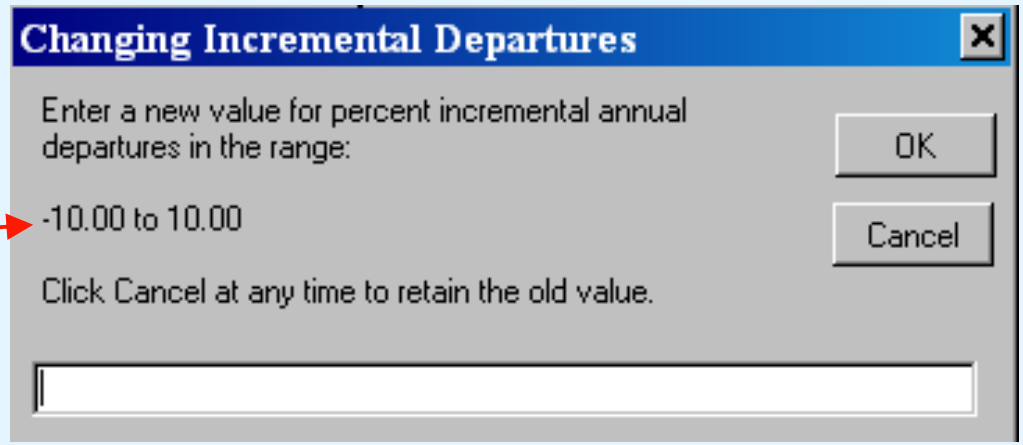
Adjusting Airplane Information – % Annual Growth of Annual Departures

Allowable range of percent annual growth is +/- 10%



You can create the same effect by modifying the annual departures such that the total annual departures results in the desired total.

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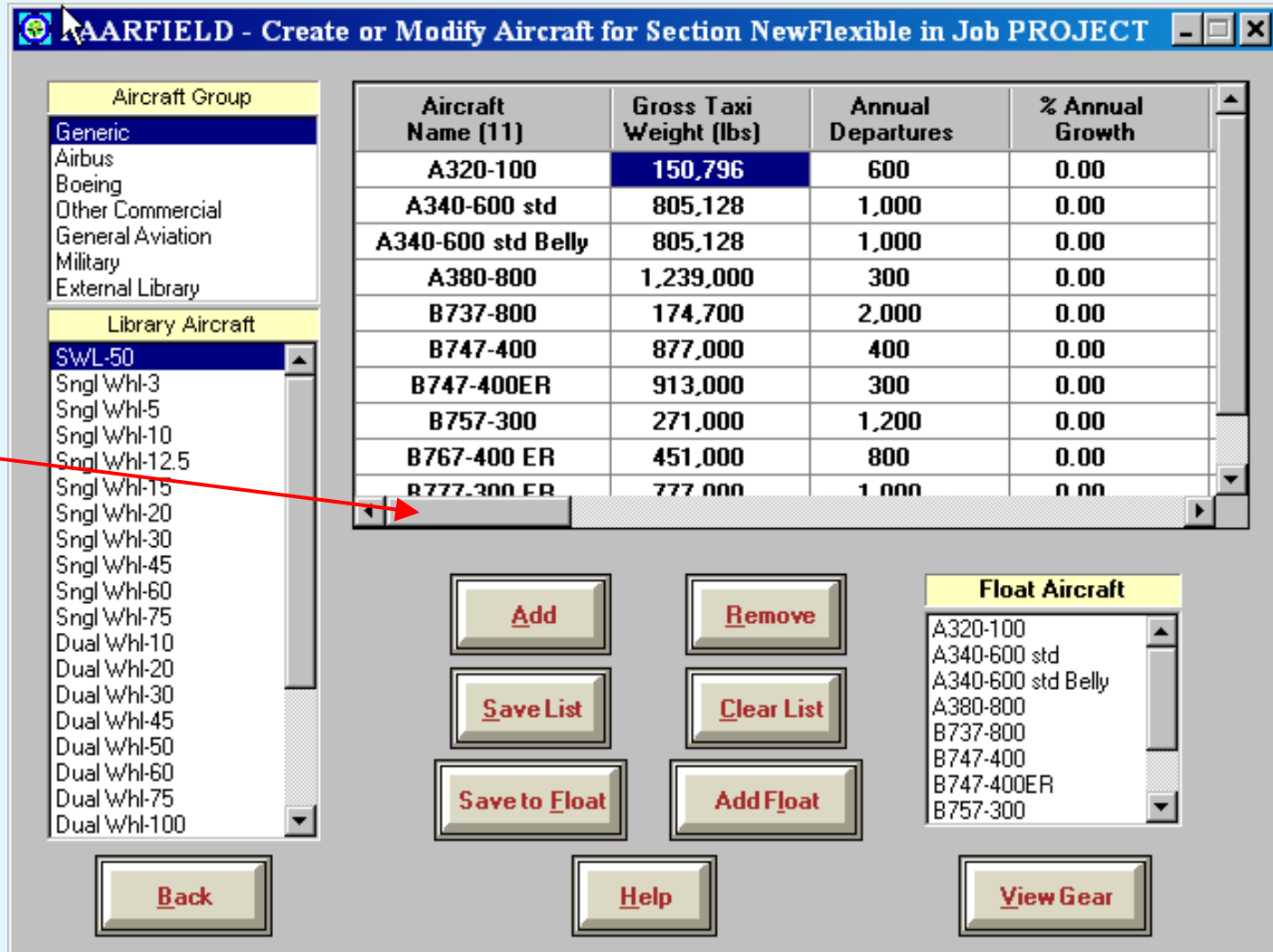
Viewing Airplane Information

Scroll over to reveal additional columns of information



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Airplane Information

Available in FAARFIELD Aircraft Screen

Aircraft Name (11)	Gross Taxi Weight (lbs)	Annual Departures	% Annual Growth	Total Departures	CDF Contribution	CDF Max for Aircraft
A320-100	150,796	600	0.00	12,000	0.00	0.00
A340-600 std	805,128	1,000	0.00	20,000	0.00	0.00
A340-600 std Belly	805,128	1,000	0.00	20,000	0.00	0.00
A380-800	1,239,000	300	0.00	6,000	0.00	0.00
B737-800	174,700	2,000	0.00	40,000	0.00	0.00
B747-400	877,000	400	0.00	8,000	0.00	0.00
B747-400ER	913,000	300	0.00	6,000	0.00	0.00
B757-300	271,000	1,200	0.00	24,000	0.00	0.00
B767-400 ER	451,000	800	0.00	16,000	0.00	0.00

P/C Ratio	Tire Press. (psi)	Percent GW on Gear	Dual Spacing (in)	Tandem Spacing (in)	Tire Contact Width (in)	Tire Contact Length (in)
0.00	200	47.5	36.50	0.00	11.93	19.09
0.00	233	32.8	55.00	78.00	15.02	24.04
0.00	222	29.3	46.00	78.00	14.55	23.28
0.00	194	95.0	53.10	66.90	15.54	24.86
0.00	205	47.5	34.00	0.00	12.69	20.31
0.00	200	95.0	44.00	58.00	14.39	23.03
0.00	230	95.0	44.00	58.00	13.70	21.91
0.00	195	47.5	34.00	45.00	11.46	18.34
0.00	215	47.5	45.80	54.00	14.08	22.53

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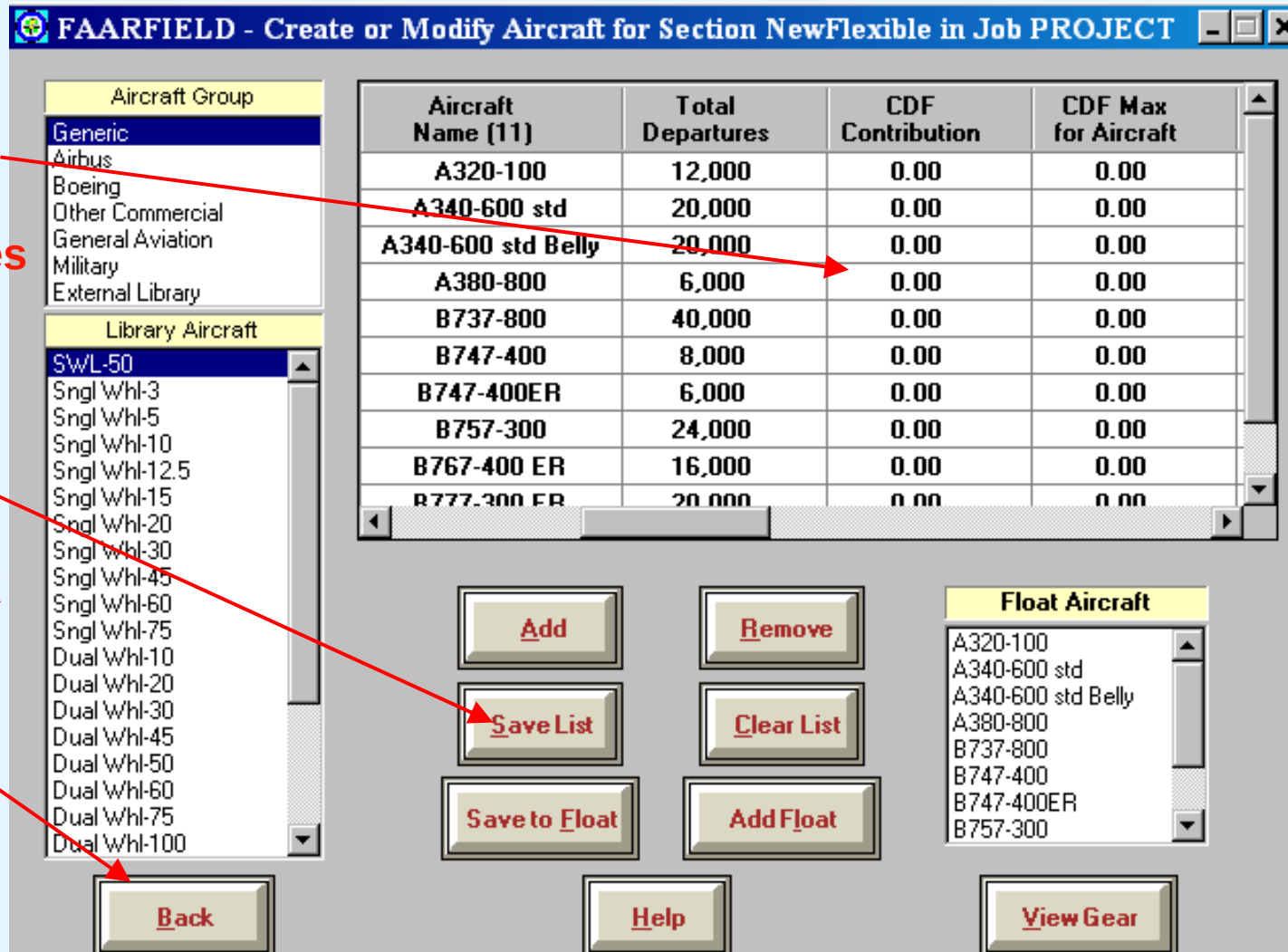
Viewing Airplane Information

CDF columns and P/C ratio will be zero when airplanes are first entered

Save the list when finished entering airplanes then click the back button



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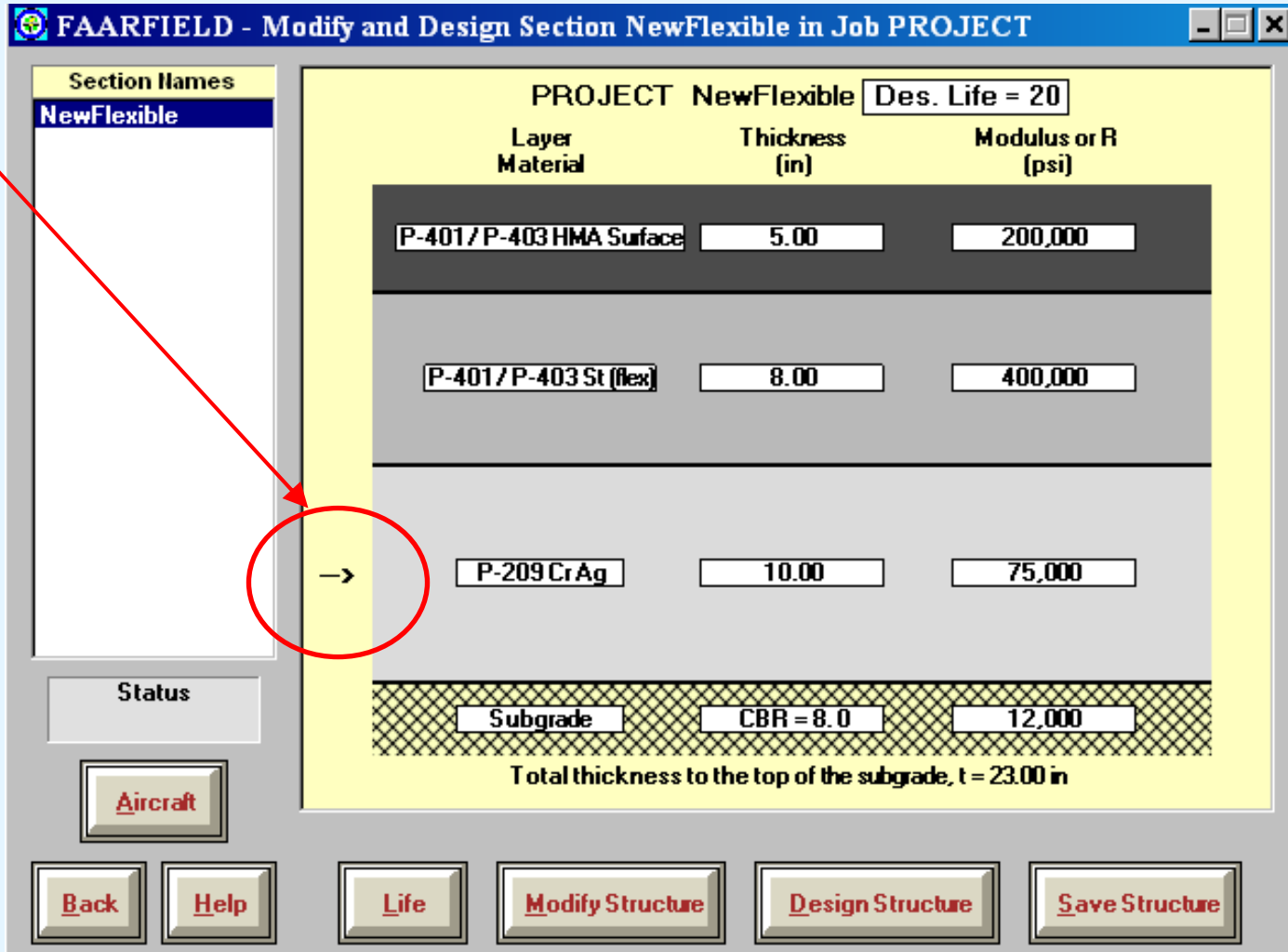
Performing the Pavement Design

The layer with the small arrow is the layer that will be adjusted to provide the structural design

The location of the arrow is determined by the type of pavement structure



FAARFIELD Flexible Pavement Design

Layered Adjusted During Design

PAVEMENT TYPE	LAYER ADJUSTED
ACAggregate	P-154 Subbase
AConFlex	P-401 AC Overlay
AConRigid	P-401 AC Overlay
NewFlexible	P-209 subbase
NewRigid	PCC Surface
PCConFlex	PCC Overlay on Flex
PCConRigid	PCC Overlay Unbond

For New flexible sections the arrow can be moved by double clicking next to the desired base or subbase layer during “modify design” mode.

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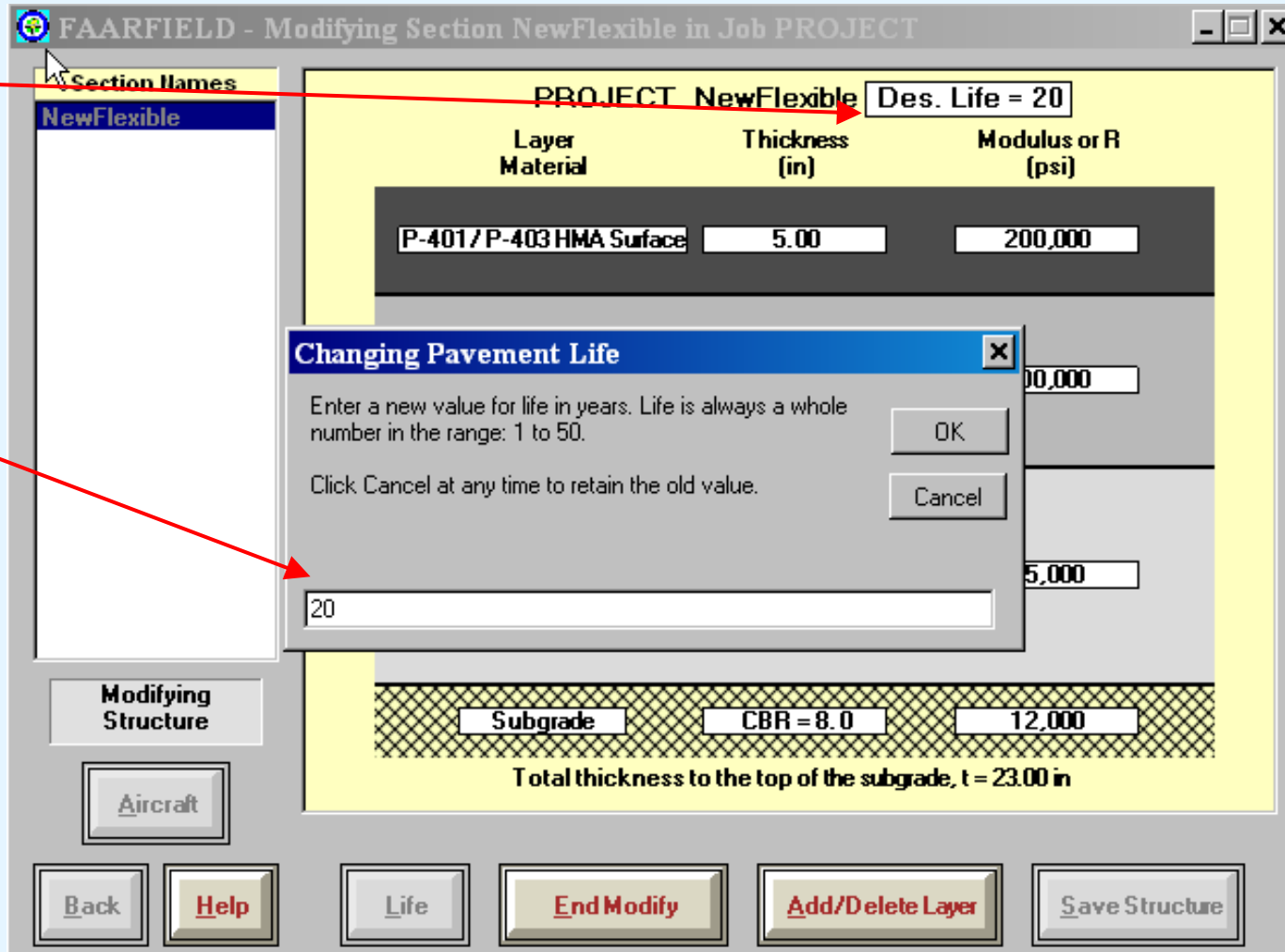
Design Life

Click on the "des. Life" to change number of years for the design period.

When the pop-up box appears, enter the desired number of years.

NOTE: the standard FAA design is for 20 years



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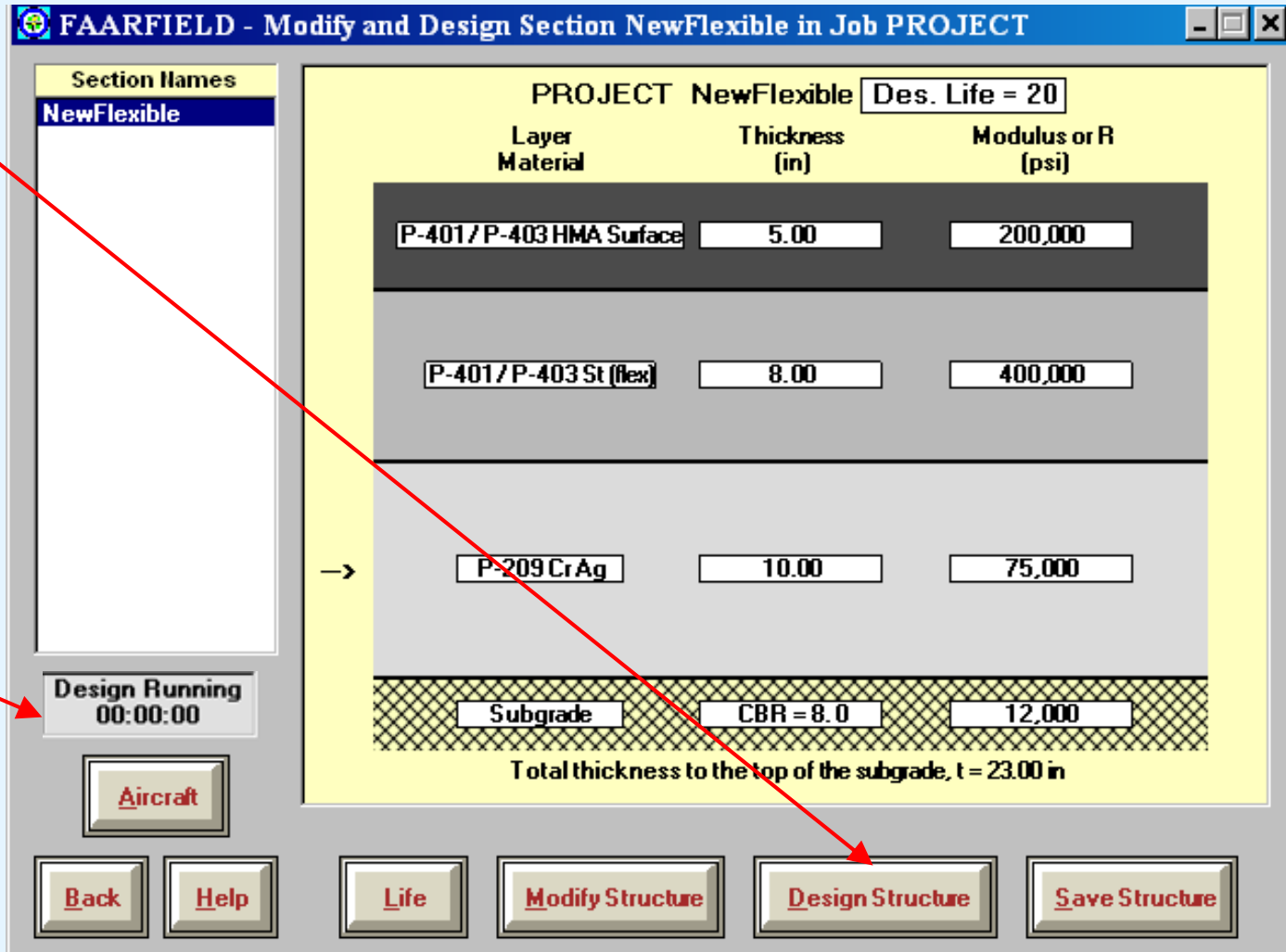
Performing the Pavement Design

You are now ready to design the structure.
Simply click on "Design Structure"

The program will keep you informed about the status of the design



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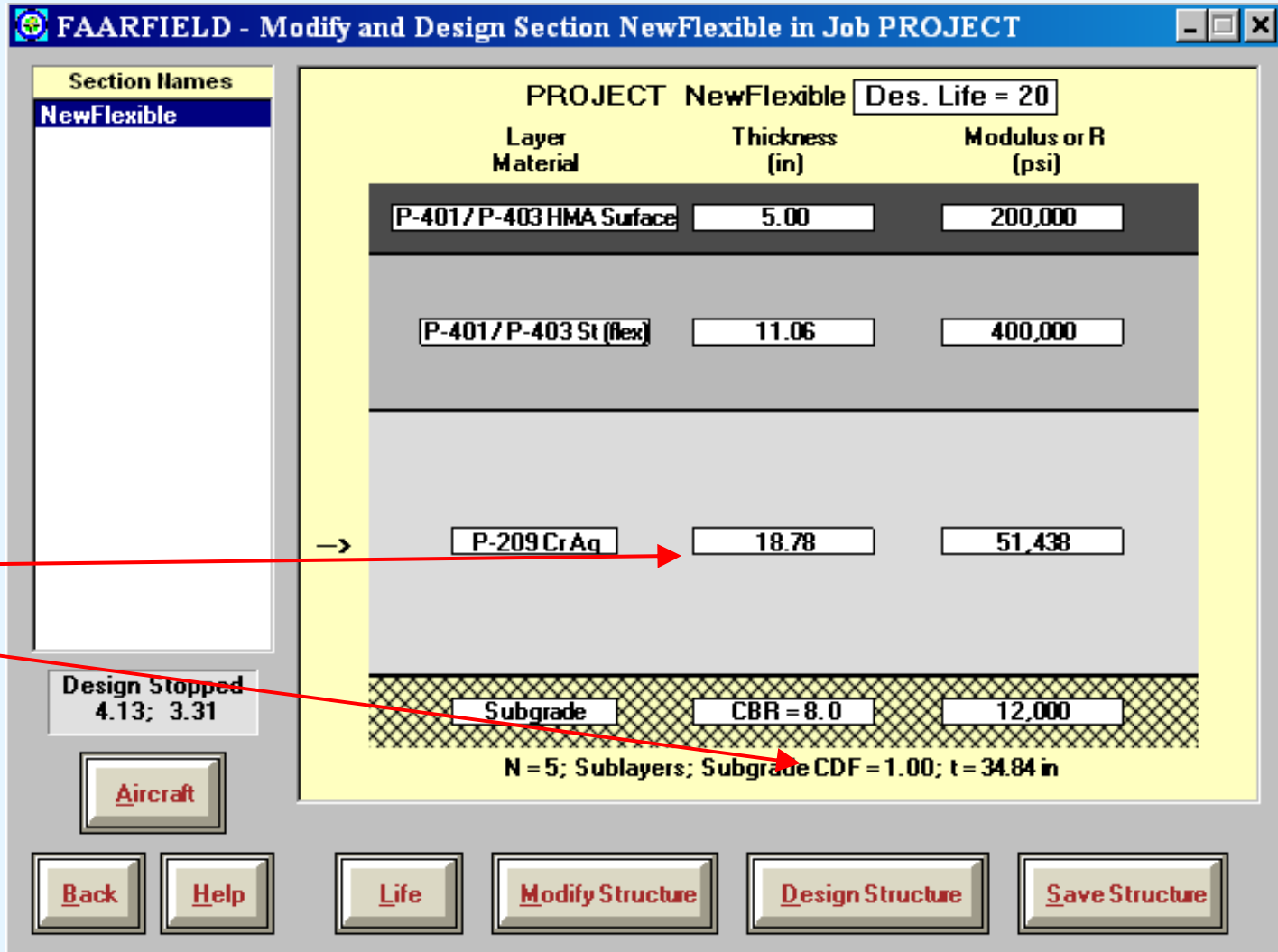
Result of the Pavement Design

The program will adjust the design layer until a CDF of 1.0 is achieved



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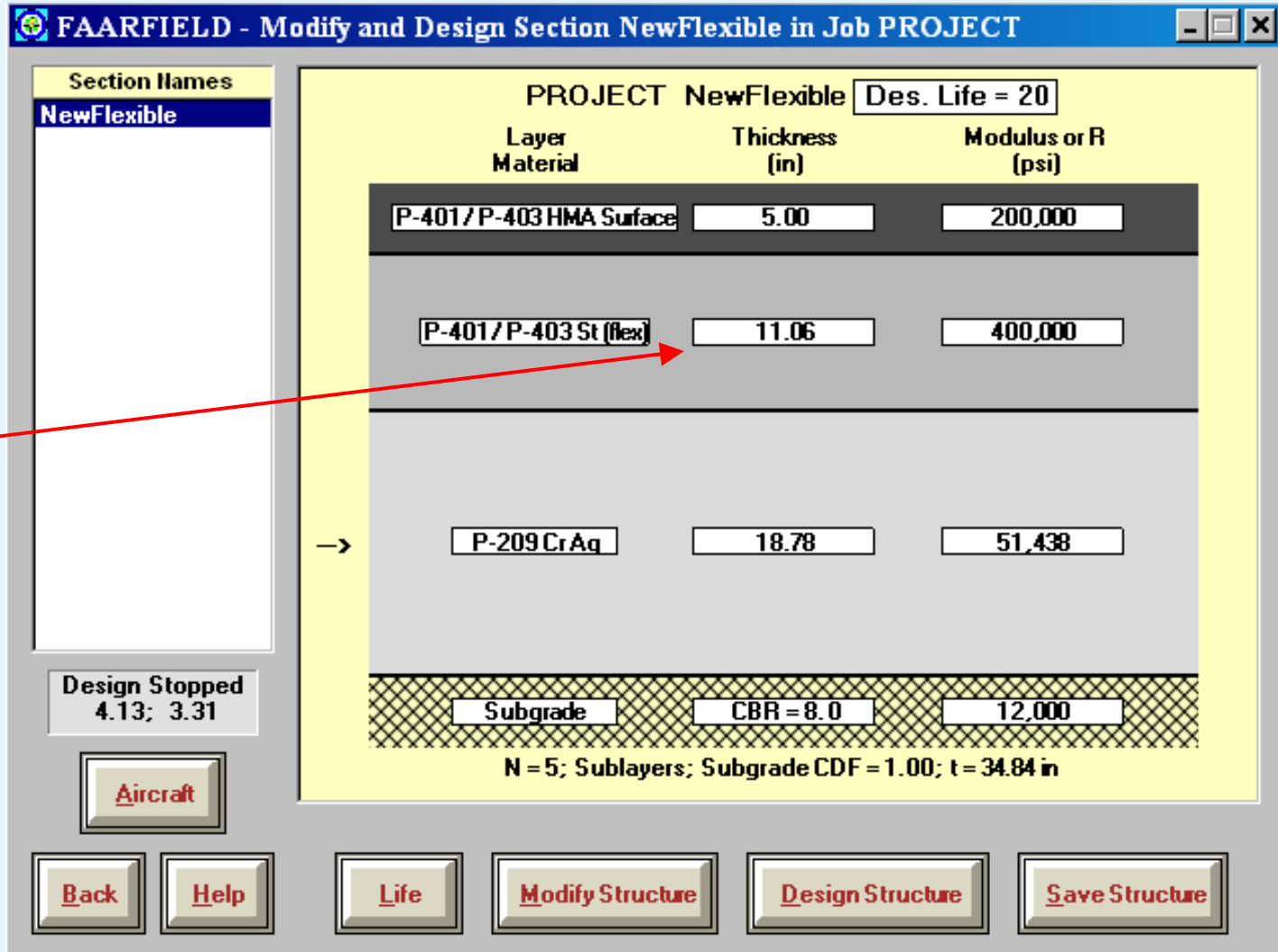
Result of the Pavement Design

The program has also determined the minimum base layer requirement



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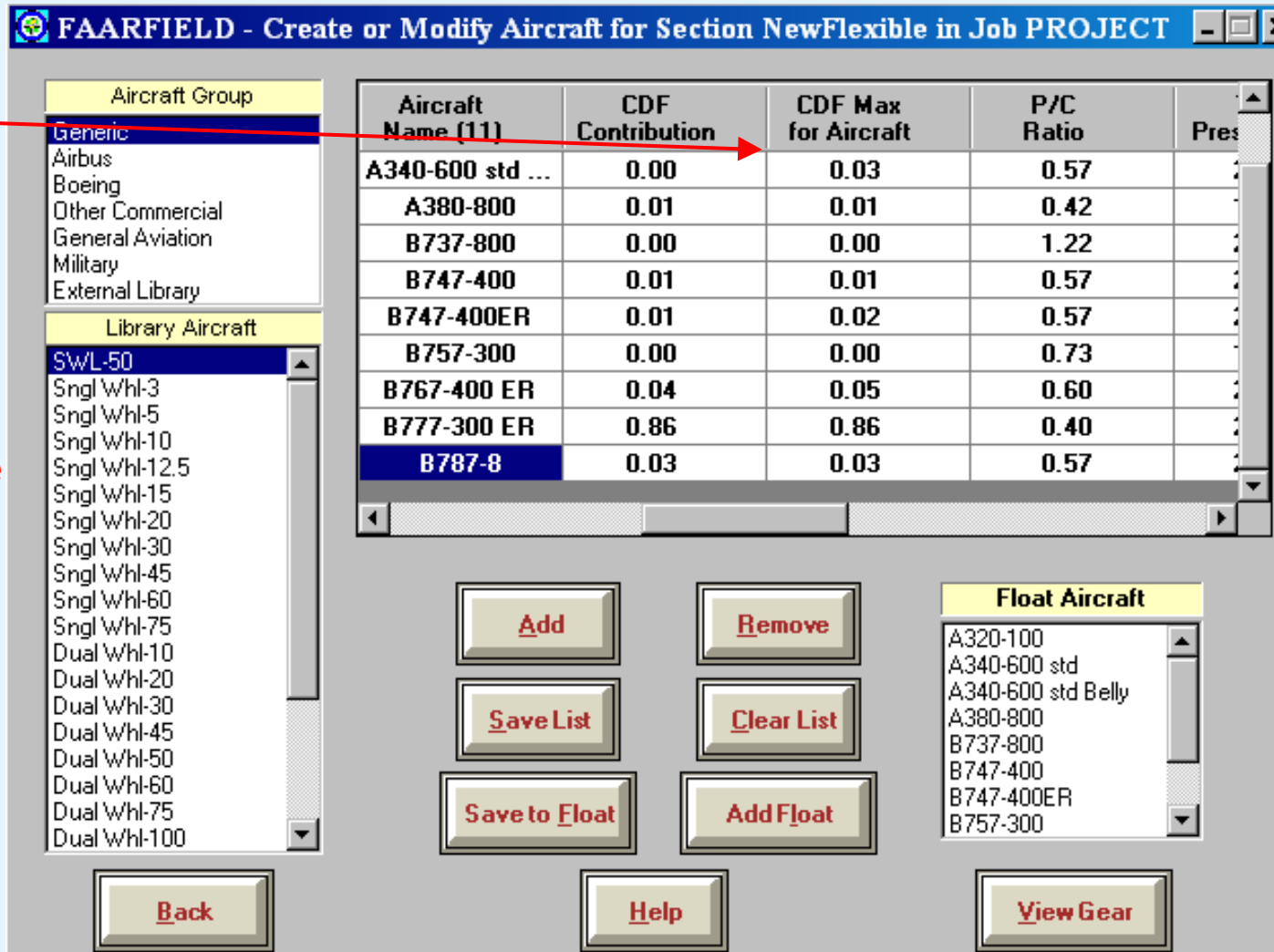
Reviewing Airplane Data After Completing the Design

CDF and P/C ratio information is now available

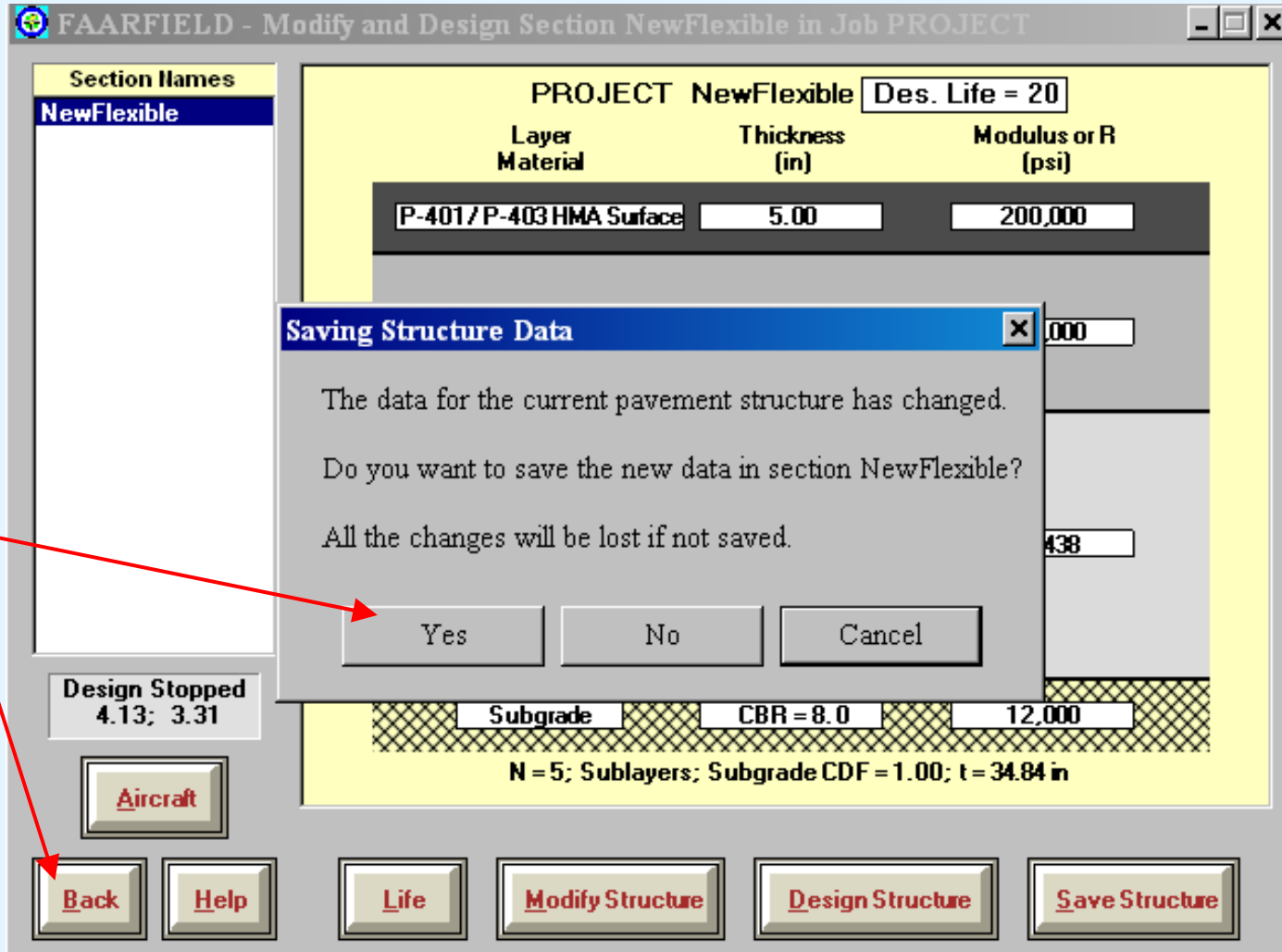
This information allows you to see which airplane have the largest impact on the pavement structure



FAARFIELD Flexible Pavement Design

Saving and Reviewing the Pavement Design Data

When finished with the design, click the "Back" button and select whether you want to save the data



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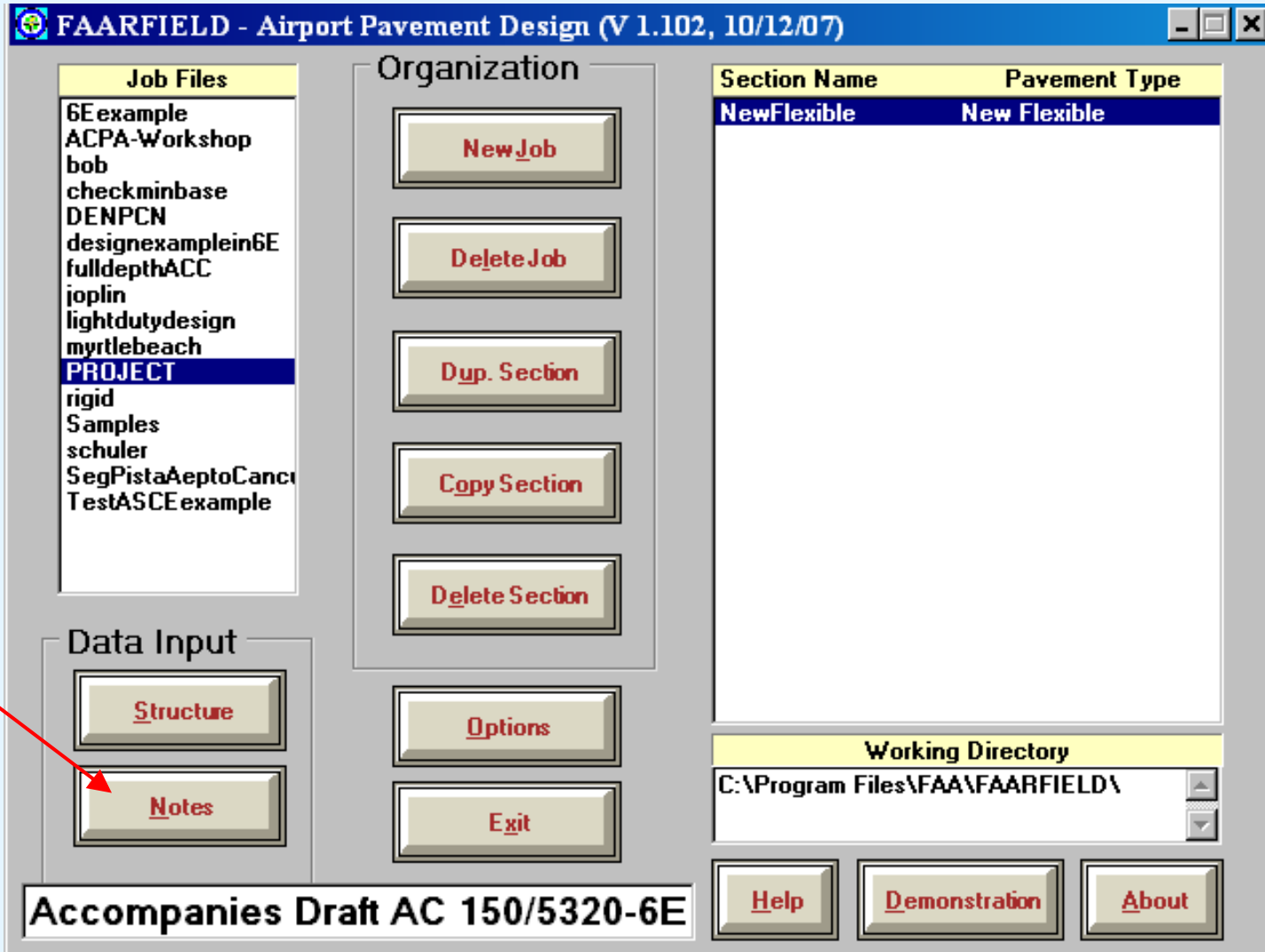
Reviewing Design Information

To view a summary of the design click the "Notes" button



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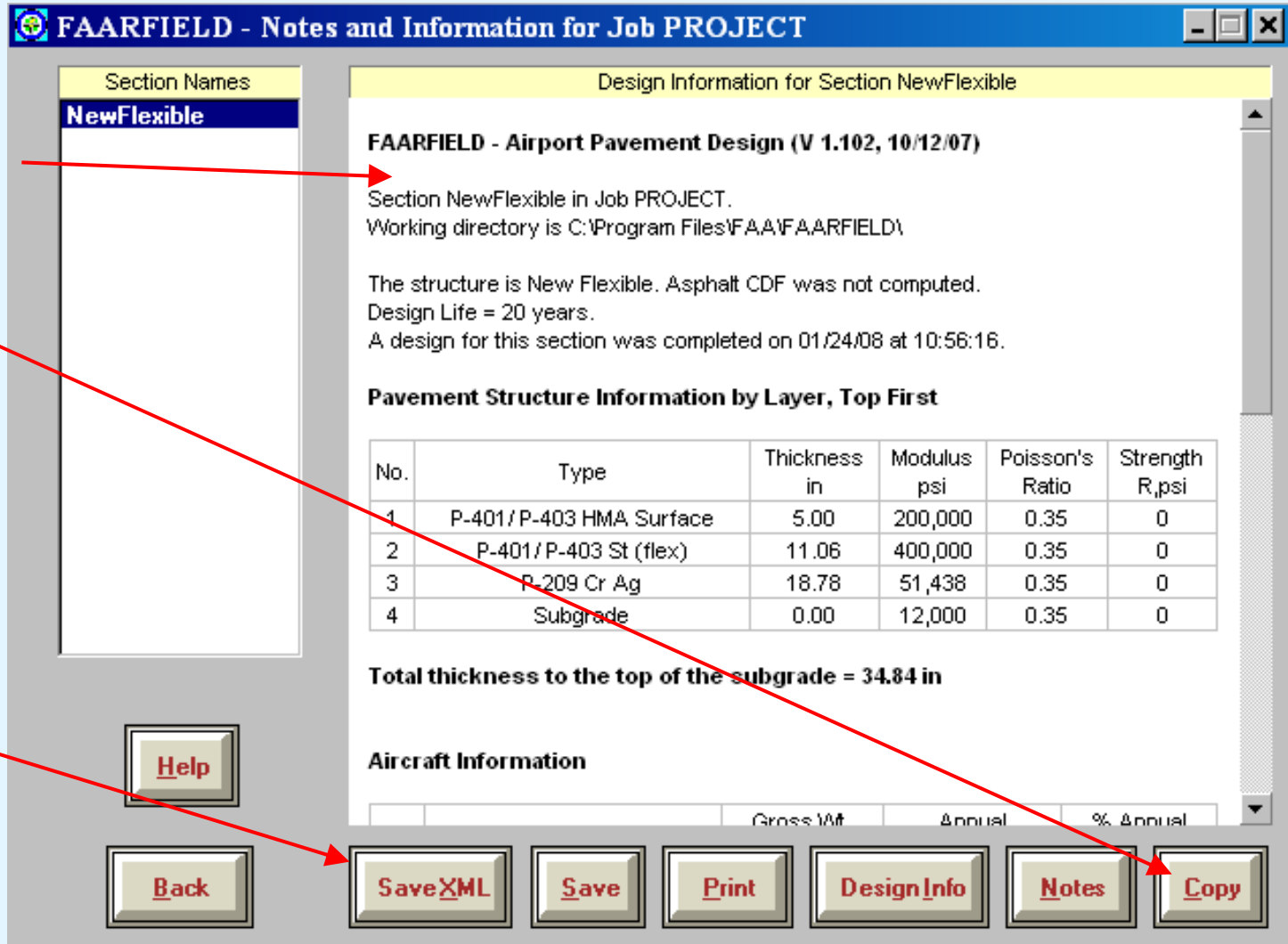
Reviewing Design Information

You can view the summary data or copy it to other electronic media

Data can also be exported in XML to allow automated entry into FAA Form 5100



FAARFIELD Flexible Pavement Design

Reviewing Design Information

FAARFIELD - Airport Pavement Design (V 1.102, 10/12/07)

Section NewFlexible in Job PROJECT.
Working directory is C:\Program Files\FAA\FAARFIELD\

The structure is New Flexible. Asphalt CDF was not computed.
Design Life = 20 years.
A design for this section was completed on 01/24/08 at 10:56:16.

Pavement Structure Information by Layer, Top First

No.	Type	Thickness in	Modulus psi	Poisson's Ratio	Strength R,psi
1	P-401/ P-403 HMA Surface	5.00	200,000	0.35	0
2	P-401/ P-403 St (flex)	11.06	400,000	0.35	0
3	P-209 Cr Ag	18.78	51,438	0.35	0
4	Subgrade	0.00	12,000	0.35	0

Total thickness to the top of the subgrade = 34.84 in

Aircraft Information

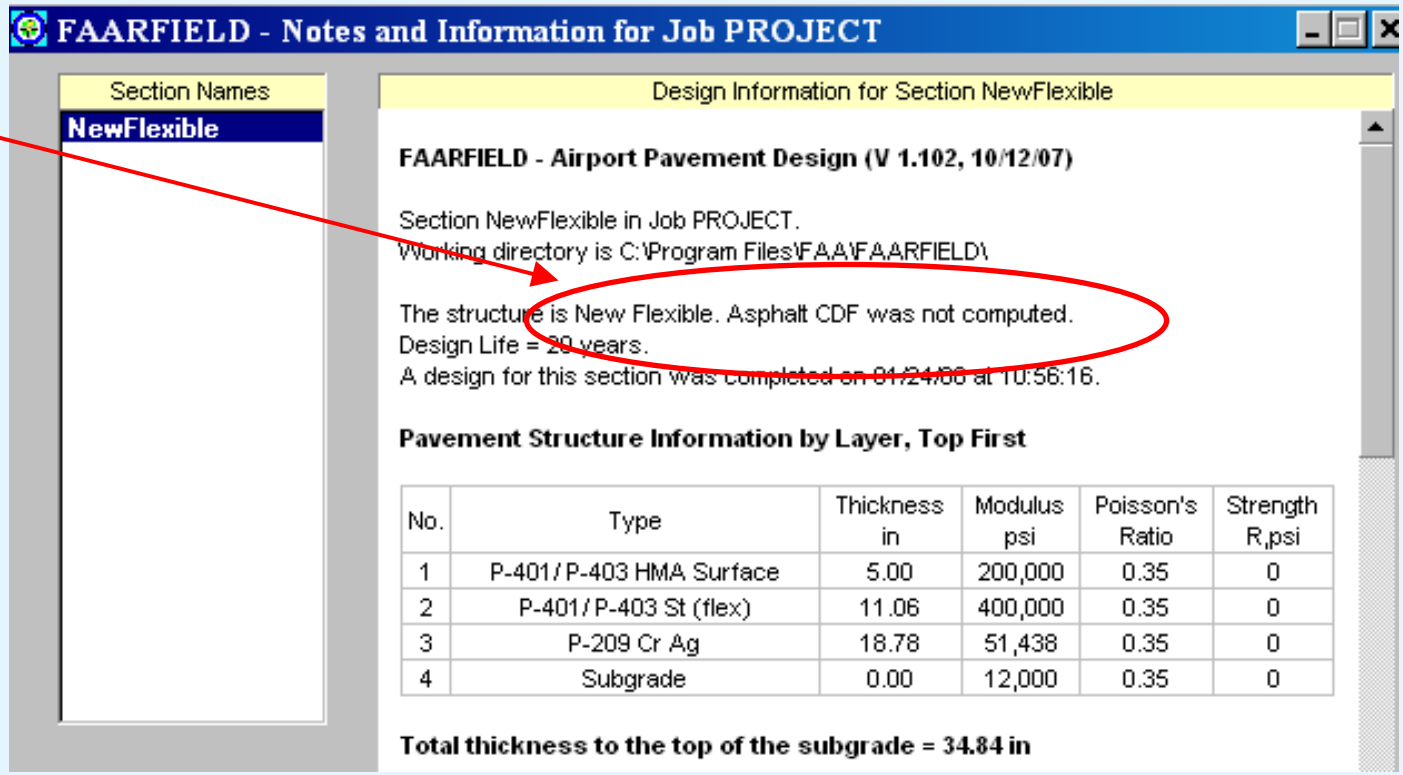
No.	Name	Gross Wt. lbs	Annual Departures	% Annual Growth	CDF Contribution	CDF Max for Aircraft	P/C Ratio
1	A320-100	150,796	600	0.00	0.00	0.00	1.21
2	A340-600 std	805,128	1,000	0.00	0.04	0.05	0.59
3	A340-600 std Belly	805,128	1,000	0.00	0.00	0.03	0.57
4	A380-800	1,239,000	300	0.00	0.01	0.01	0.42
5	B737-800	174,700	2,000	0.00	0.00	0.00	1.22
6	B747-400	877,000	400	0.00	0.01	0.01	0.57
7	B747-400ER	913,000	300	0.00	0.01	0.02	0.57
8	B757-300	271,000	1,200	0.00	0.00	0.00	0.73
9	B767-400 ER	451,000	800	0.00	0.04	0.05	0.60
10	B777-300 ER	777,000	1,000	0.00	0.86	0.86	0.40
11	B787-8	478,000	600	0.00	0.03	0.03	0.57

FAARFIELD Flexible Pavement Design

Reviewing Design Information

Notice the Statement "Asphalt CDF was not computed"

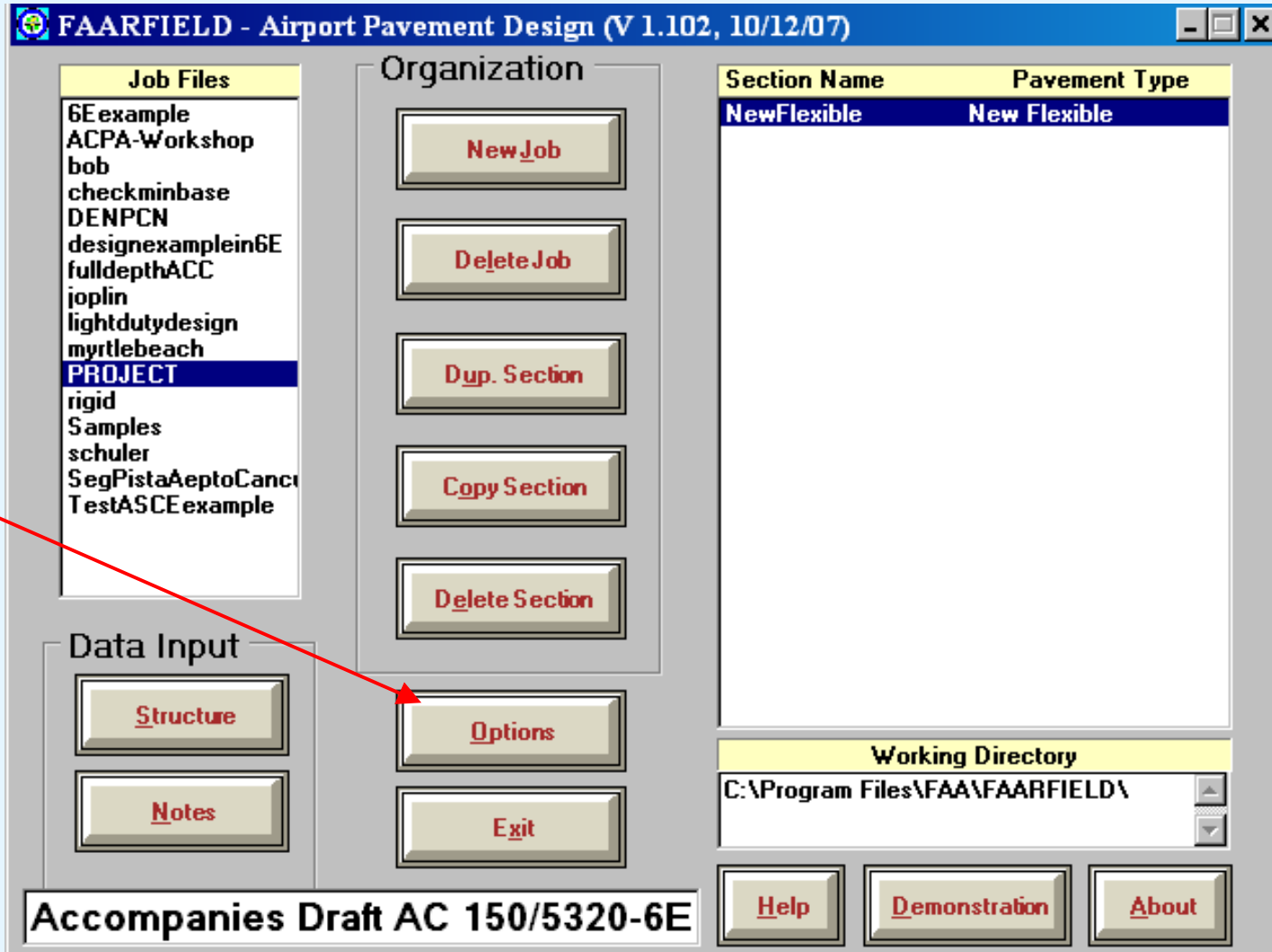
This means the design assumed the failure was in the subgrade and did not calculate the fatigue in the bottom of the asphalt layer



FAARFIELD Flexible Pavement Design

Calculating Fatigue in the Asphalt Layer

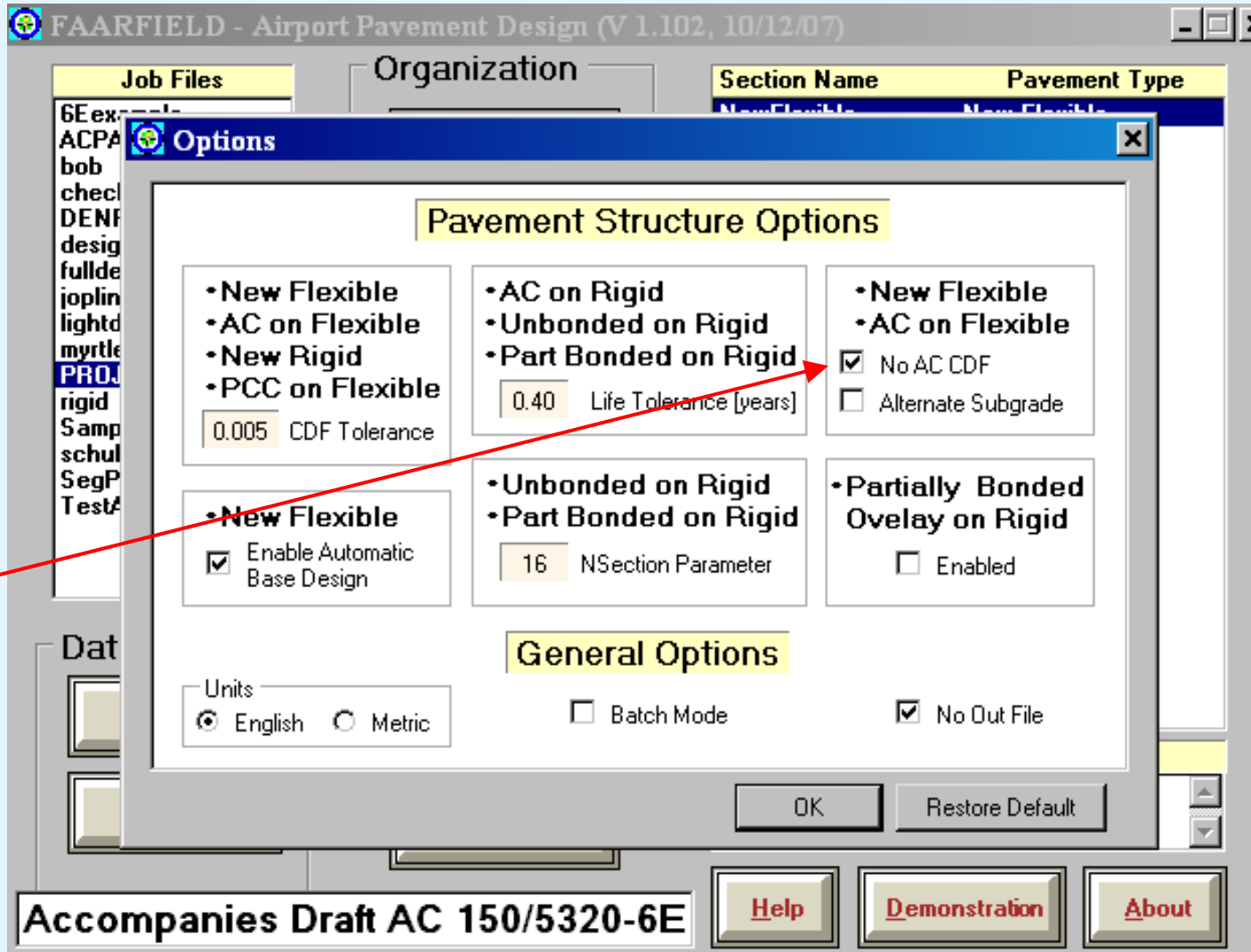
By clicking the options box the user can access the optional program features including the Asphalt layer CDF



FAARFIELD Flexible Pavement Design

Calculating Fatigue in the Asphalt Layer

If you want the program to calculate the asphalt fatigue un-check the box and re-run the design

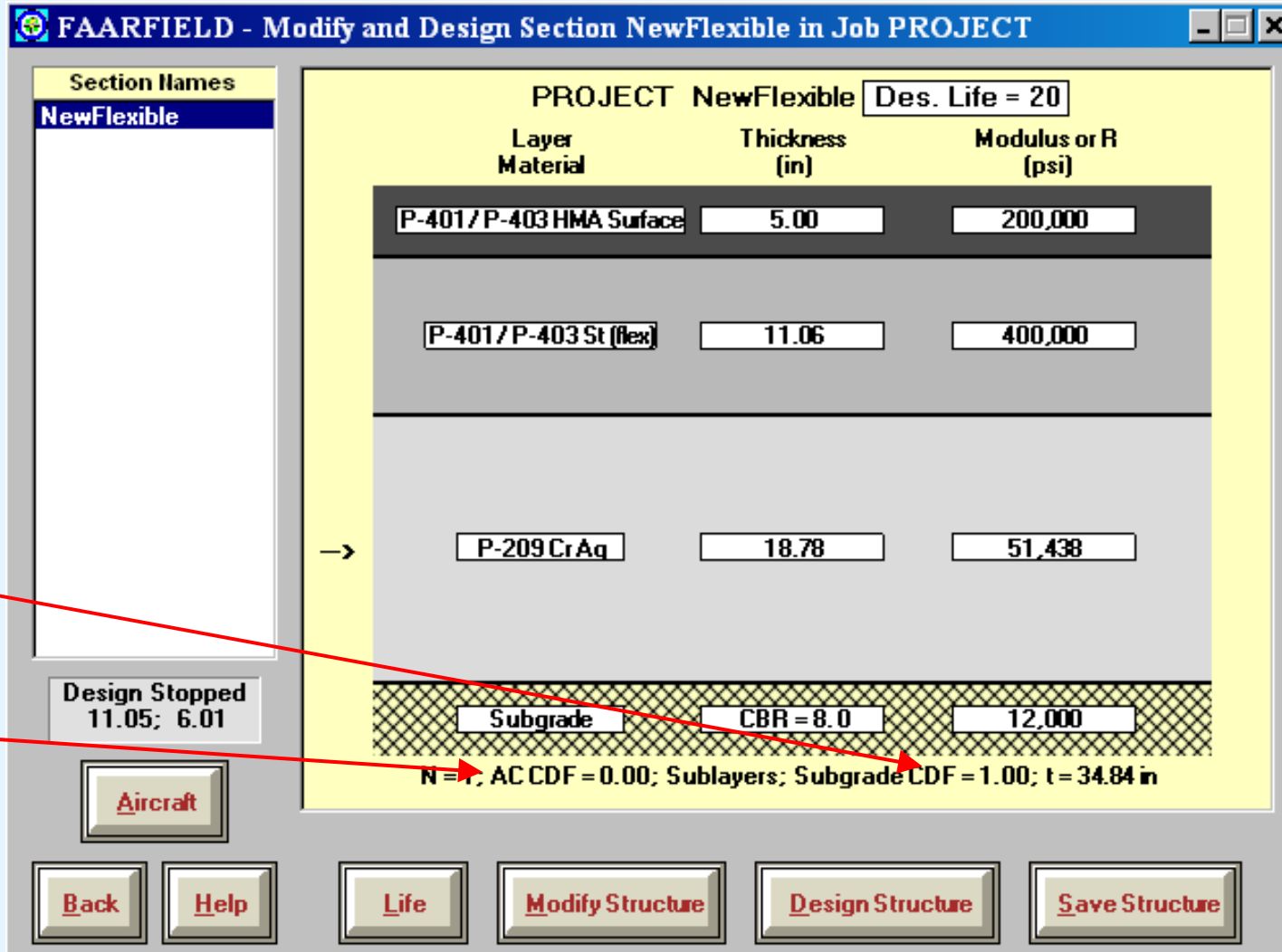


FAARFIELD Flexible Pavement Design

Calculating Fatigue in the Asphalt Layer

As this example demonstrates, the controlling feature is almost always the subgrade

i.e. subgrade CDF reaches 1.0 while the AC CDF is still 0.0



FAARFIELD Flexible Pavement Design

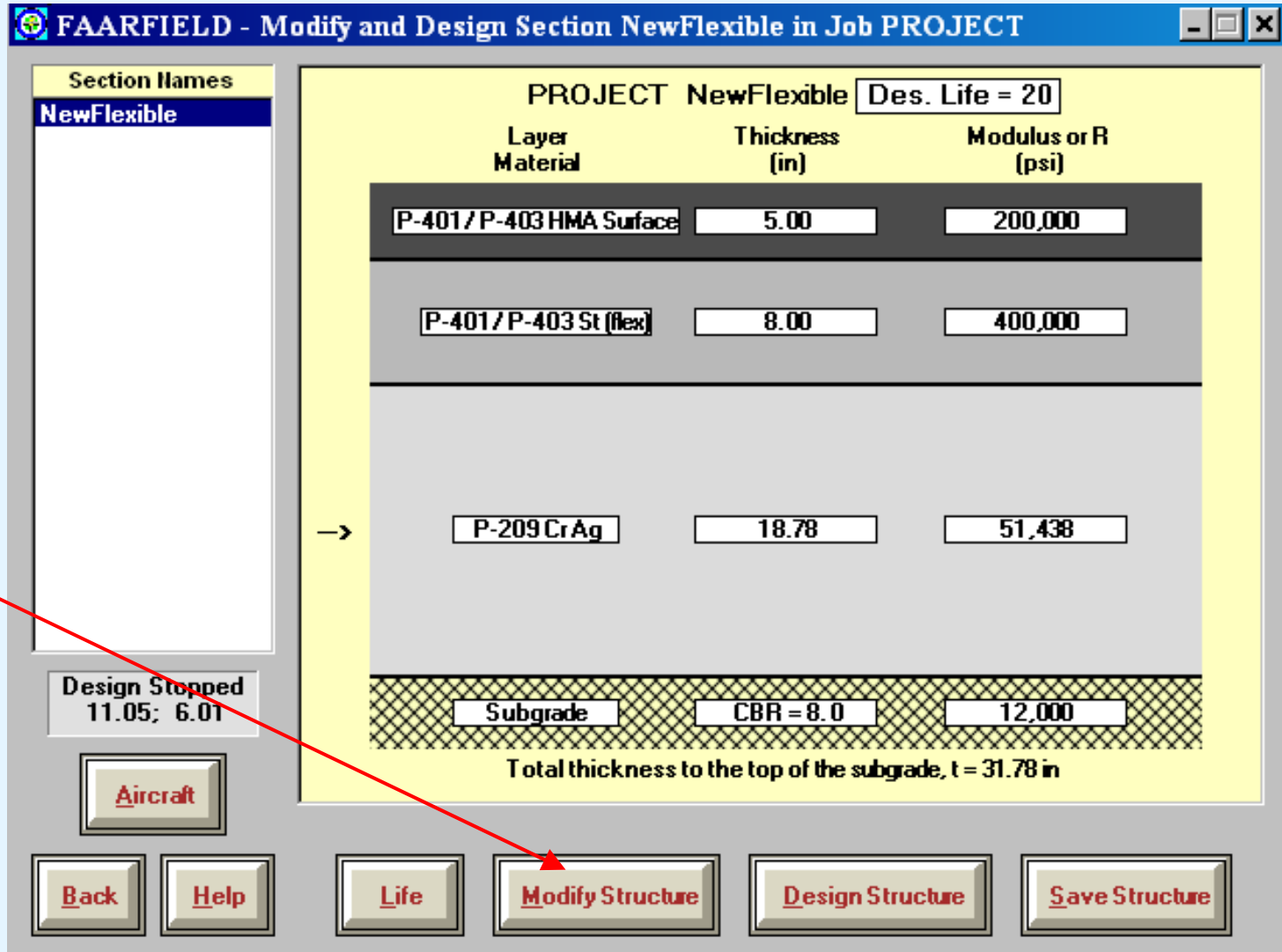
Minimum Base Course Requirements

- **FAARFIELD will automatically determine the minimum base layer requirements.**
- **Users can do this step manually if desired by deselecting this option**
  - Remove subbase layer and increase subgrade CBR to 20.
  - Re-run the design to obtain the minimum base thickness

FAARFIELD Flexible Pavement Design

Determine Minimum Base Thickness

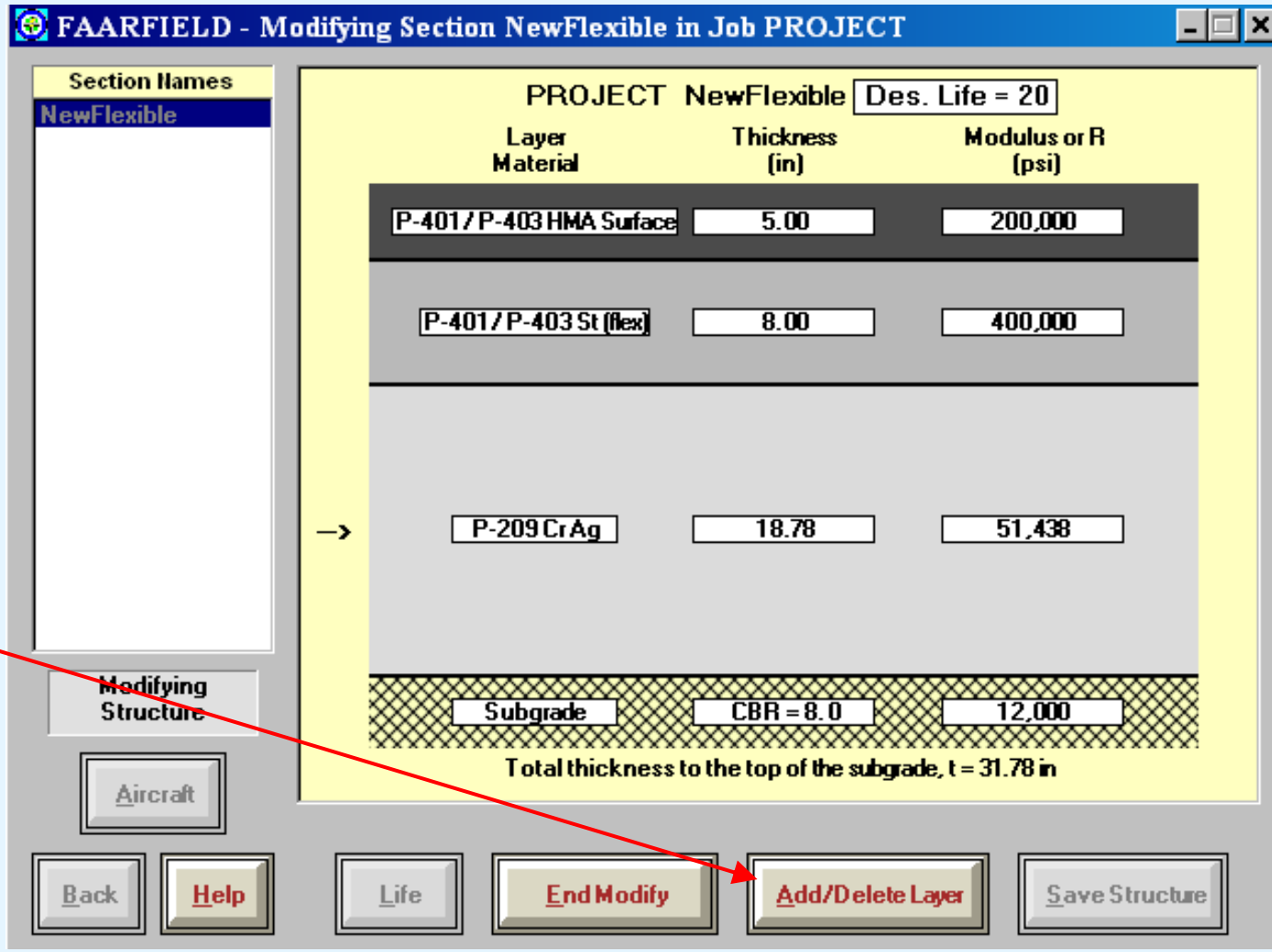
Click on “Modify Structure”



FAARFIELD Flexible Pavement Design

Determine Minimum Base Thickness

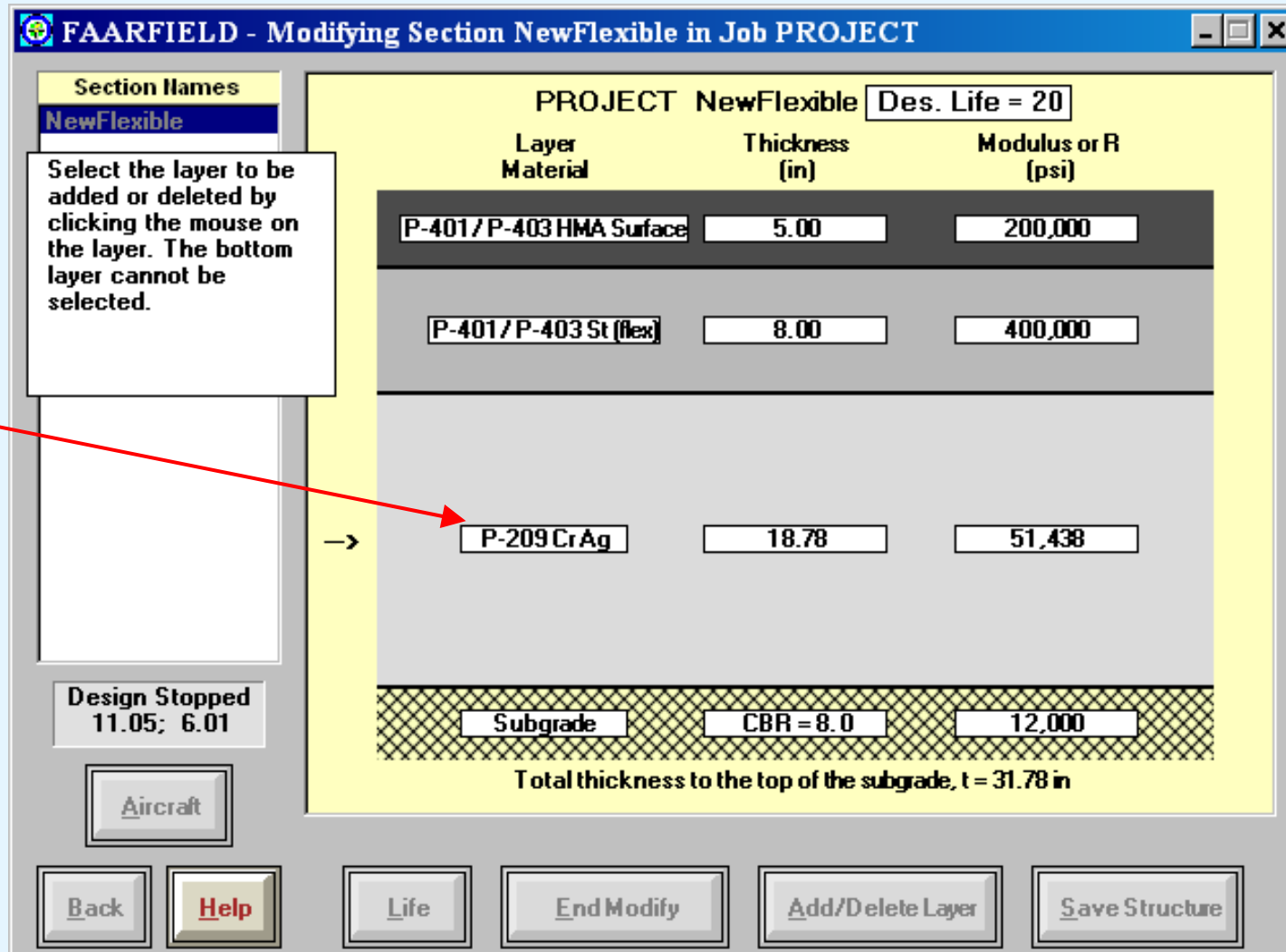
Click on
"Add/Delete Layer"



FAARFIELD Flexible Pavement Design

Determine Minimum Base Thickness

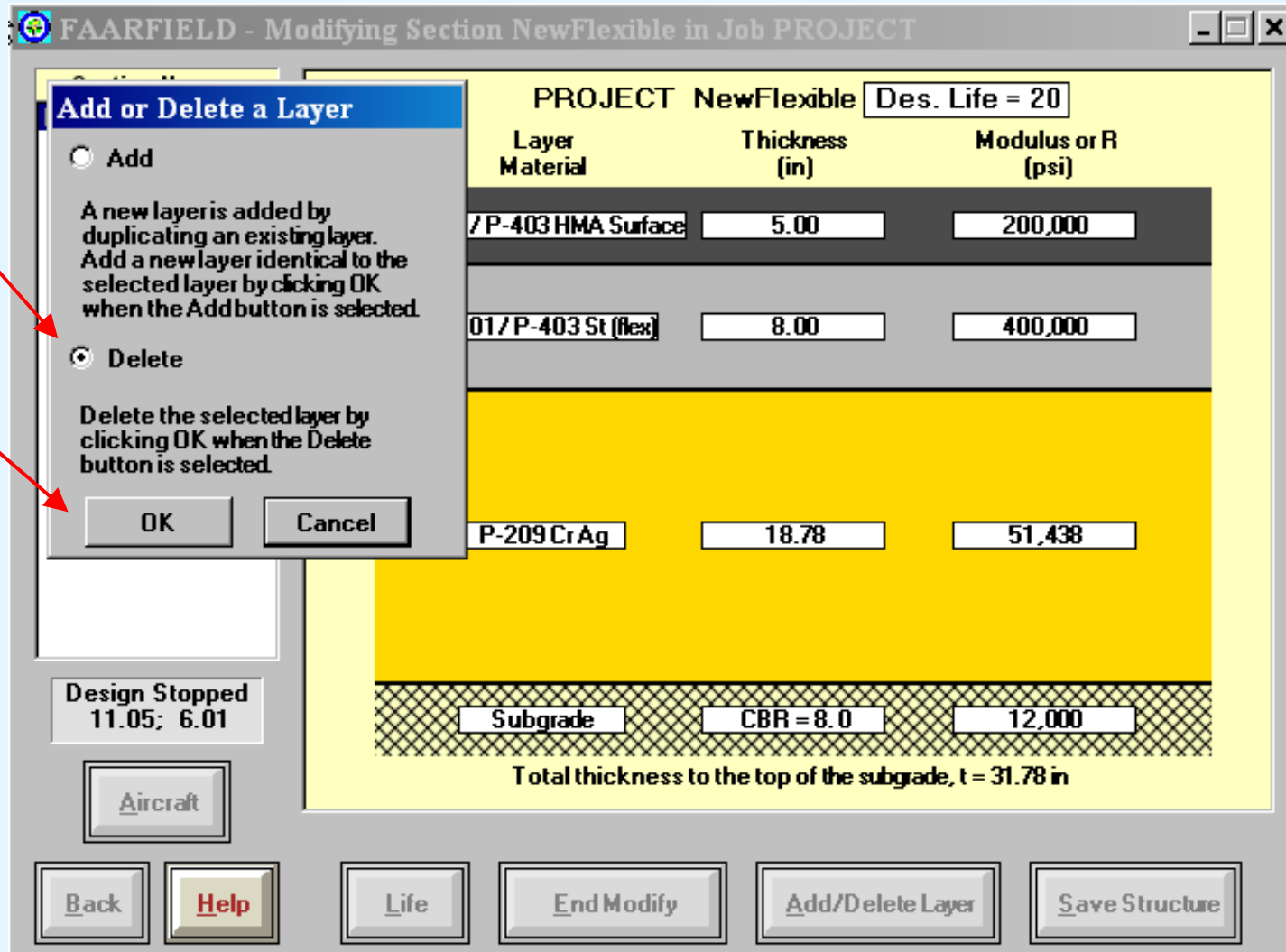
Click on the subbase layer



FAARFIELD Flexible Pavement Design

Determine Minimum Base Thickness

Check the delete option
Then click OK



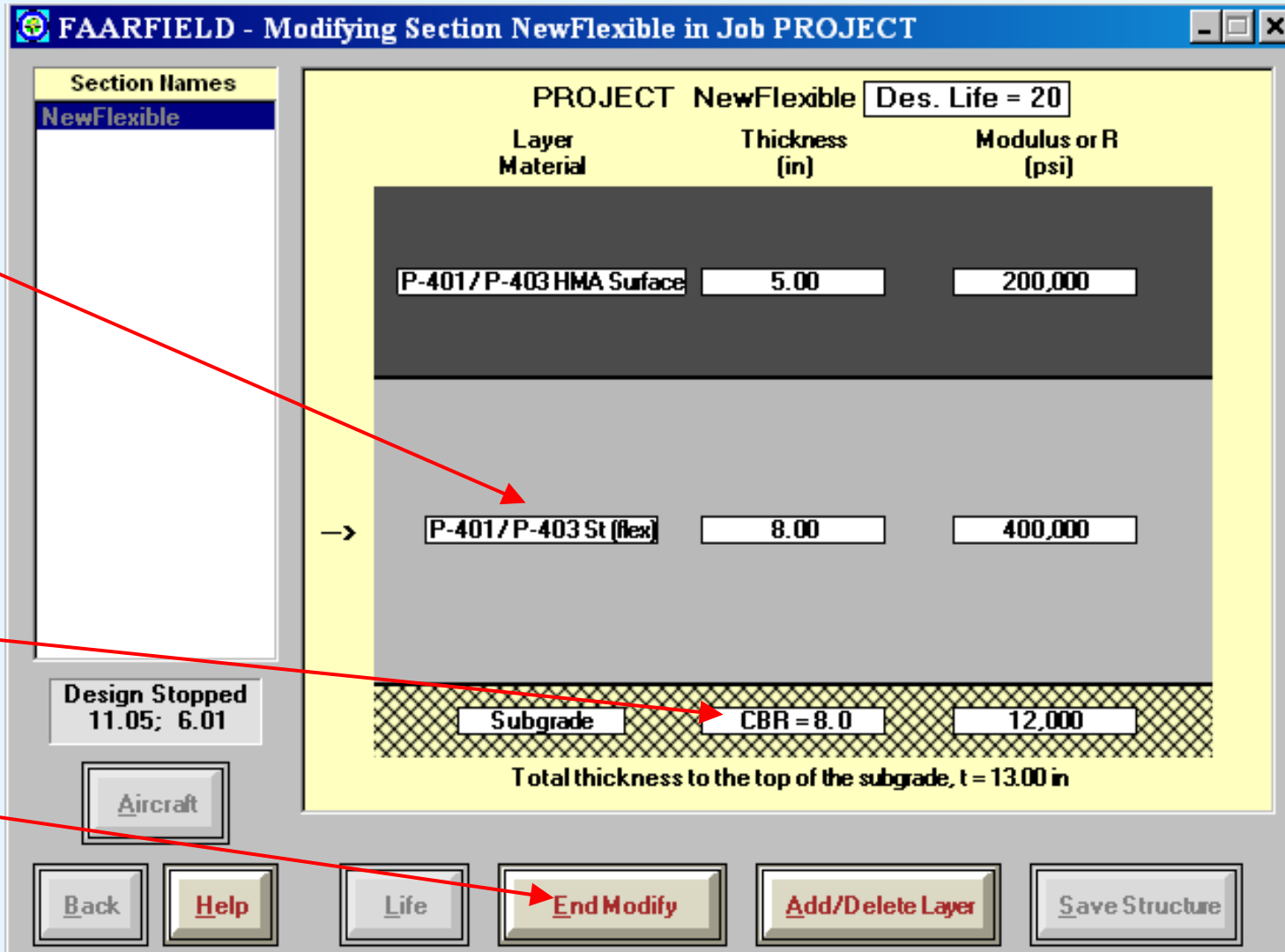
FAARFIELD Flexible Pavement Design

Determine Minimum Base Thickness

Change the P-401 Stabilized layer to P-209

Increase the subgrade CBR to 20

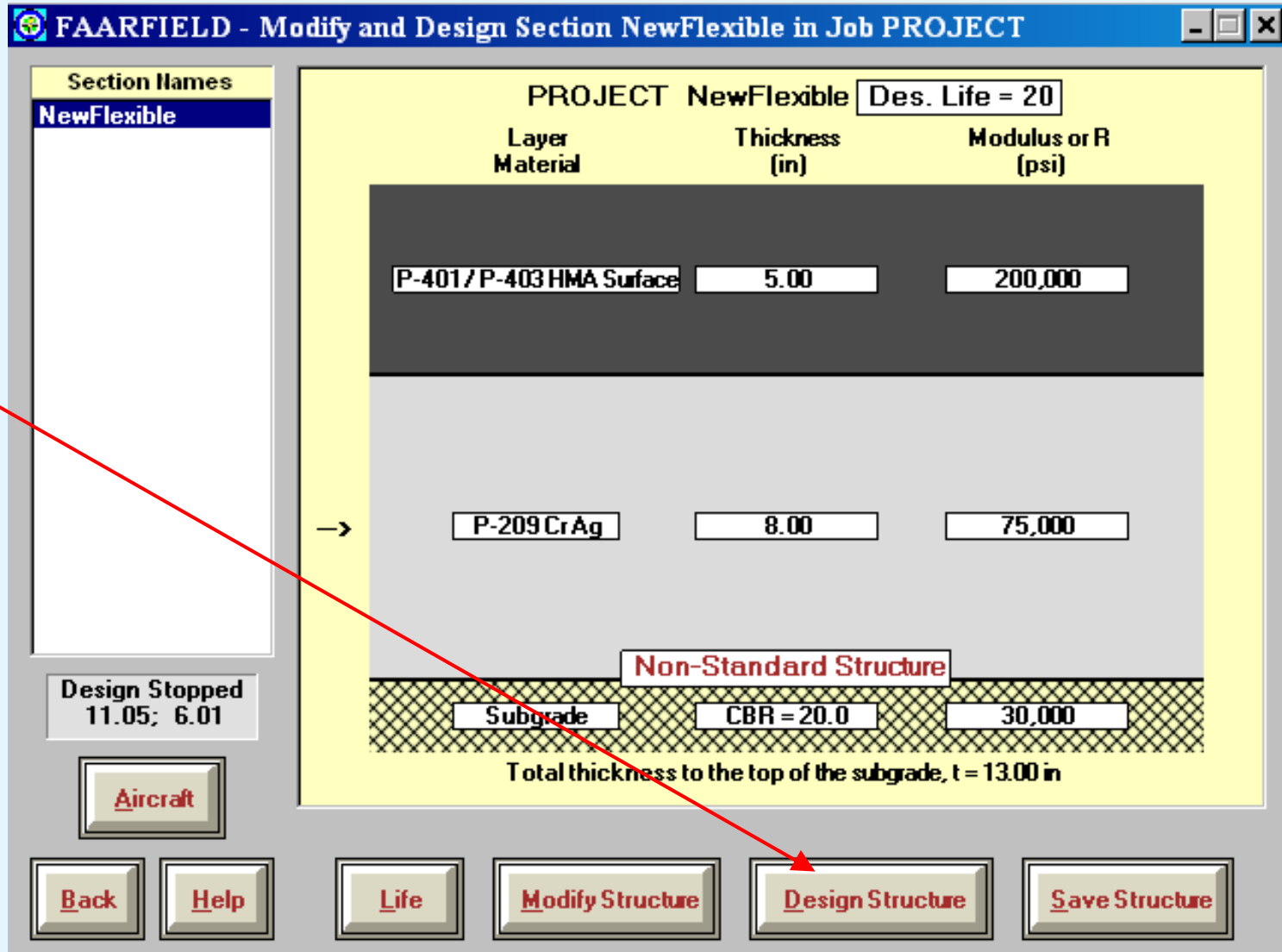
Then click “End Modify”



FAARFIELD Flexible Pavement Design

Determine Minimum Base Thickness

Click “Design Structure”

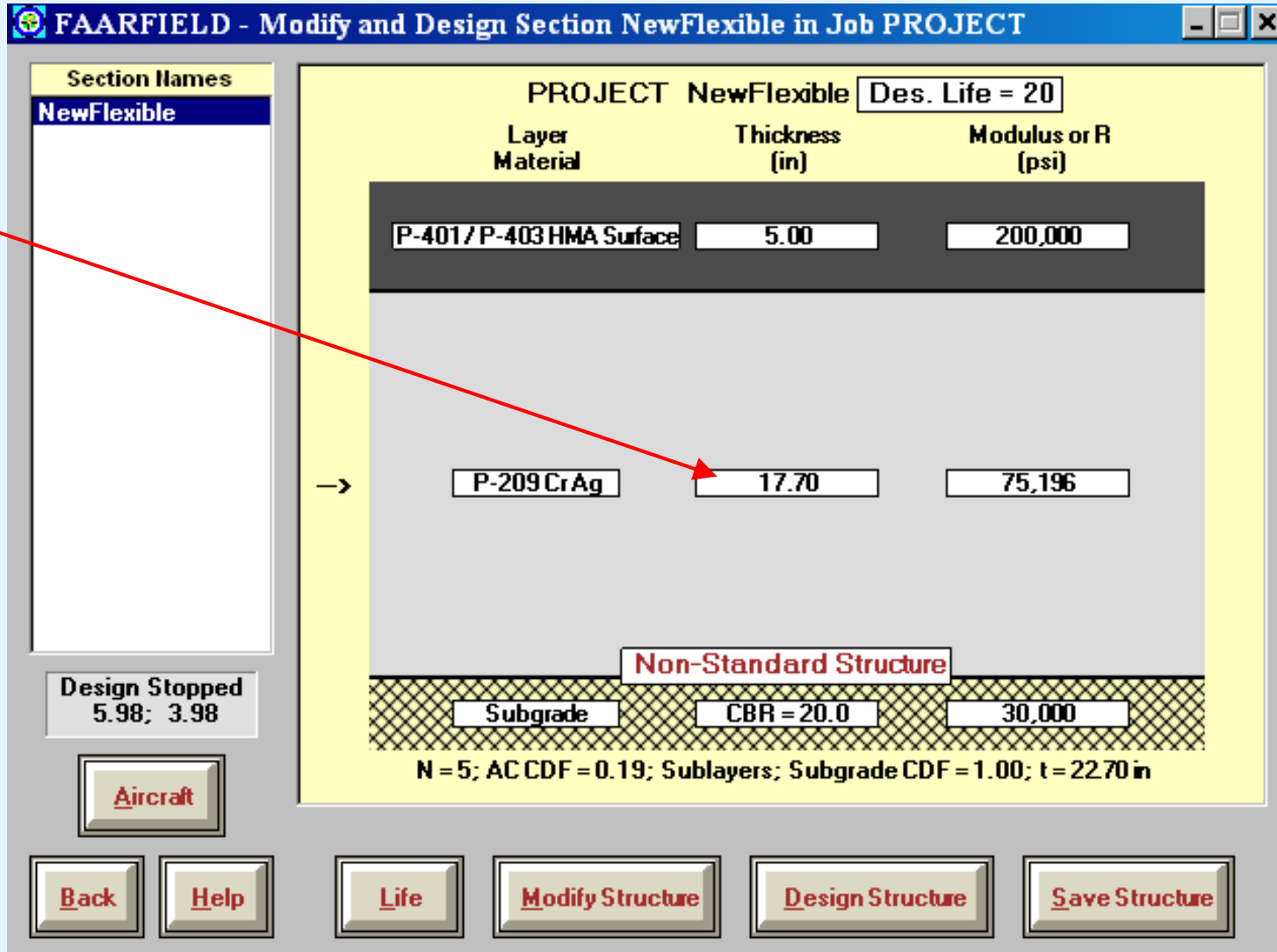


FAARFIELD Flexible Pavement Design

Determine Minimum Base Thickness

The minimum P-209 Base thickness is that necessary to protect the CBR 20 subbase material

Now convert P-209 to stabilize material



FAARFIELD Flexible Pavement Design

Determine Minimum Base Thickness

17.7 inches of P-209 is converted to Stabilized Base

For this example use P-401 as stabilized material

$T_{401Base} = T_{P209} / 1.6$ *(1.6 is provided in 5320-6E)*

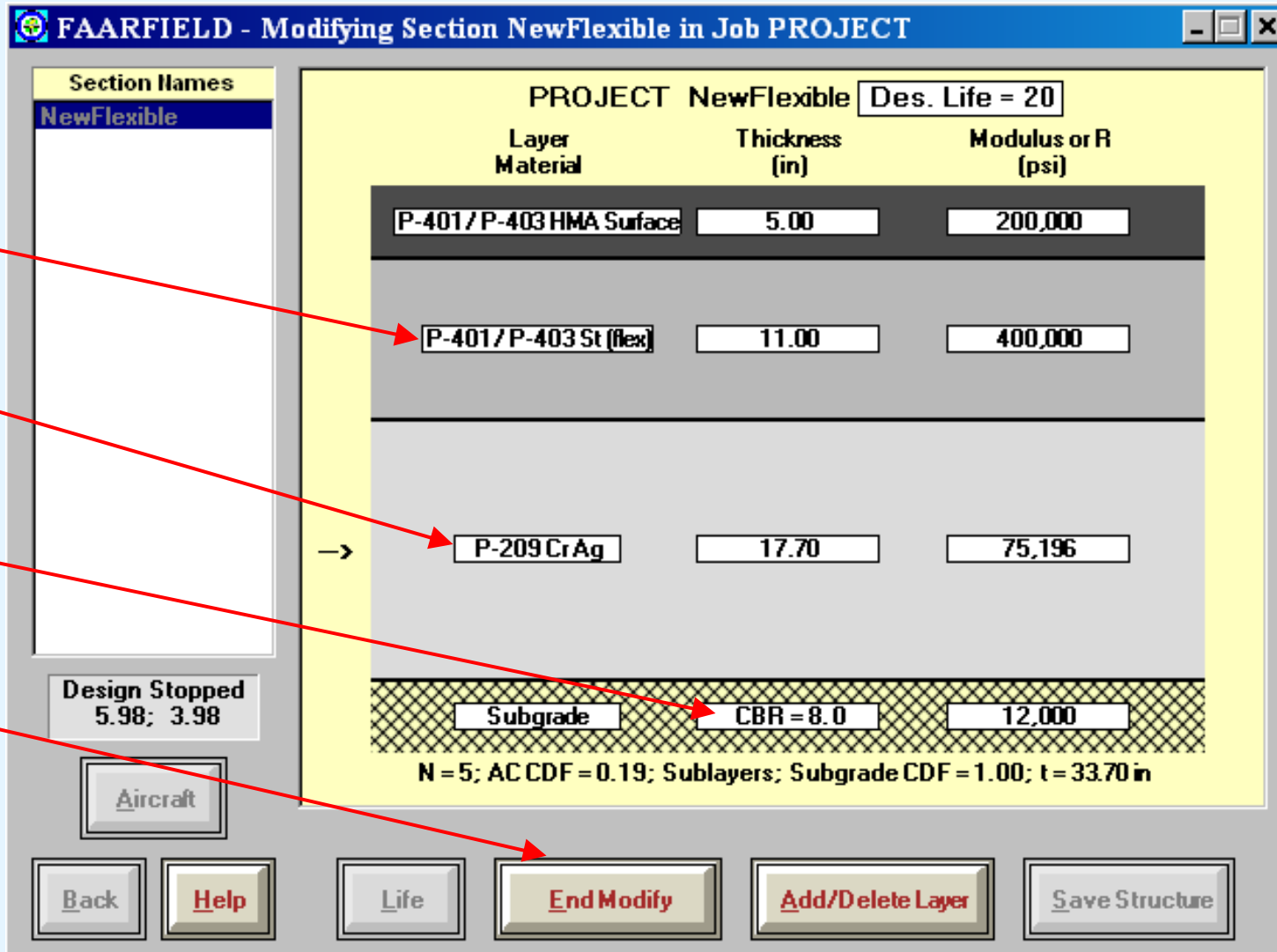
$T_{401Base} = 17.7 / 1.6 = 11.0625$ say 11.0

FAARFIELD Flexible Pavement Design

Determine Minimum Base Thickness

- Reconstruct the pavement section
- Stabilized P-401 base at 11 inches
- P-209 as the improved subbase material
- CBR returned to design value

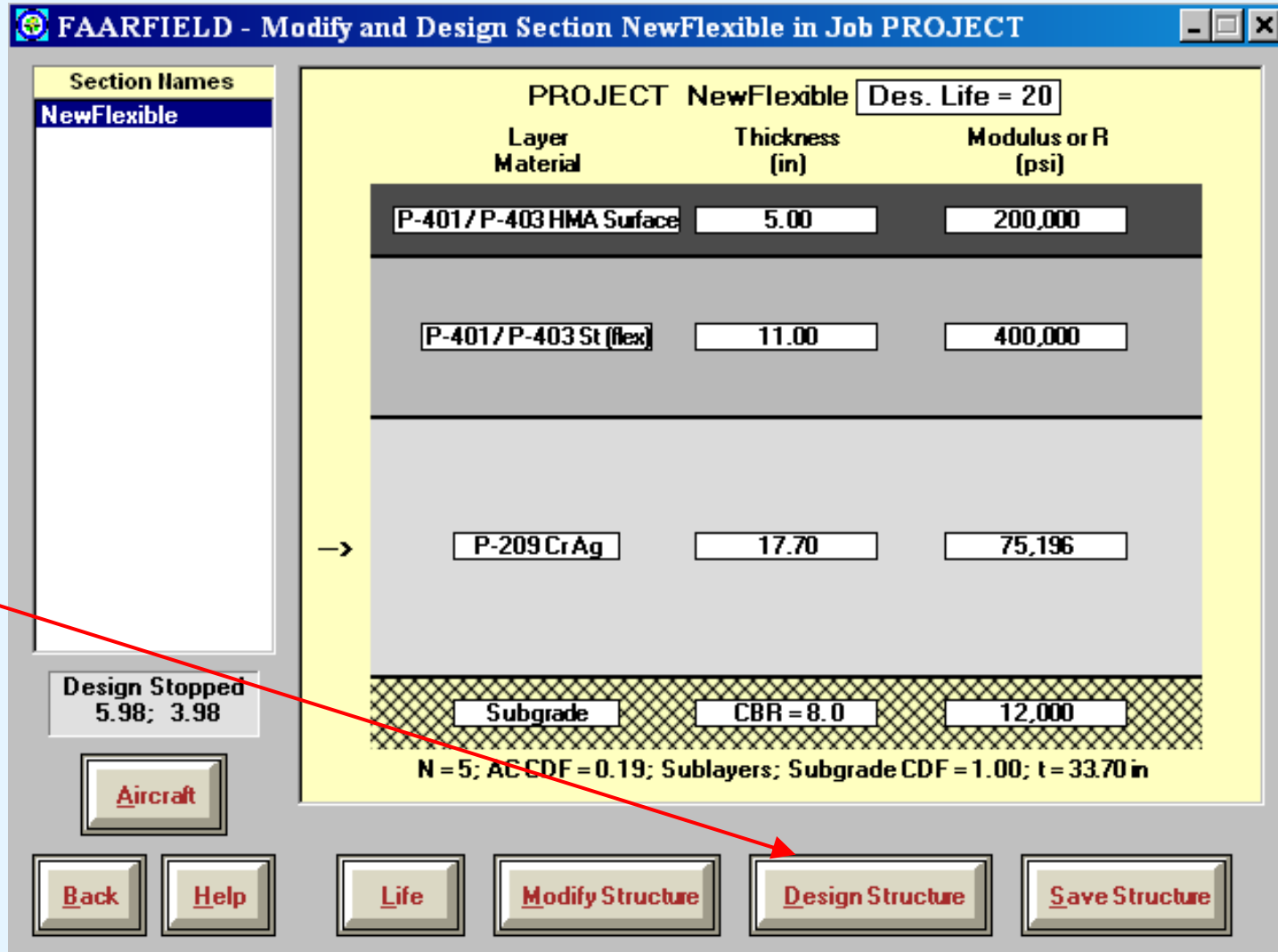
Click “End Modify”



FAARFIELD Flexible Pavement Design

Determine Minimum Base Thickness

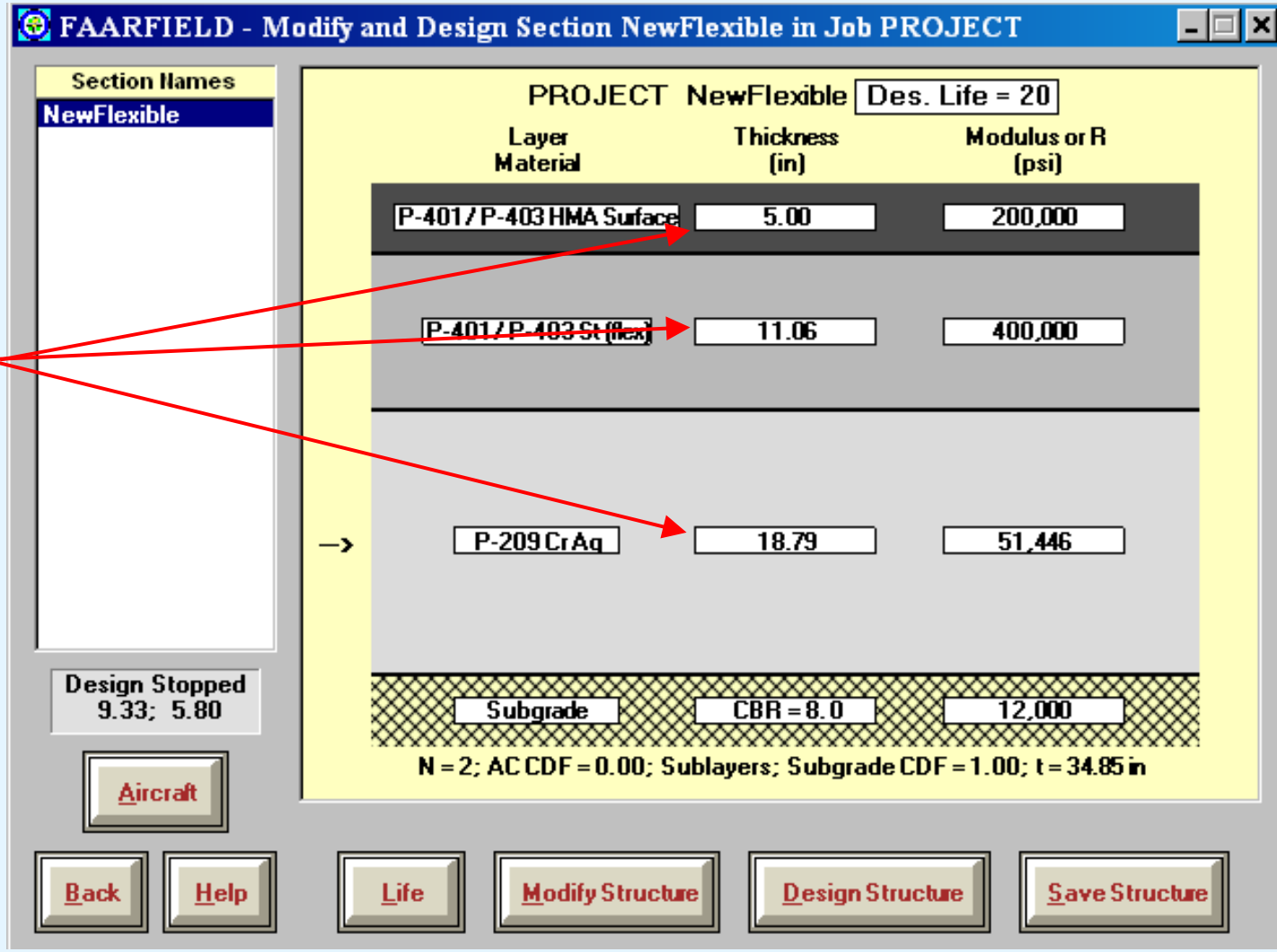
Then click “Design Structure”



FAARFIELD Flexible Pavement Design

Determine Minimum Base Thickness

The final pavement requirements are now visible



FAARFIELD - Sample HMA Overlay Design

Overlay design is very similar to new pavement design except that the design is only allowed to iterate on the overlay layer

The steps and options are similar to that of a new flexible design

FAARFIELD - Sample HMA Overlay Design

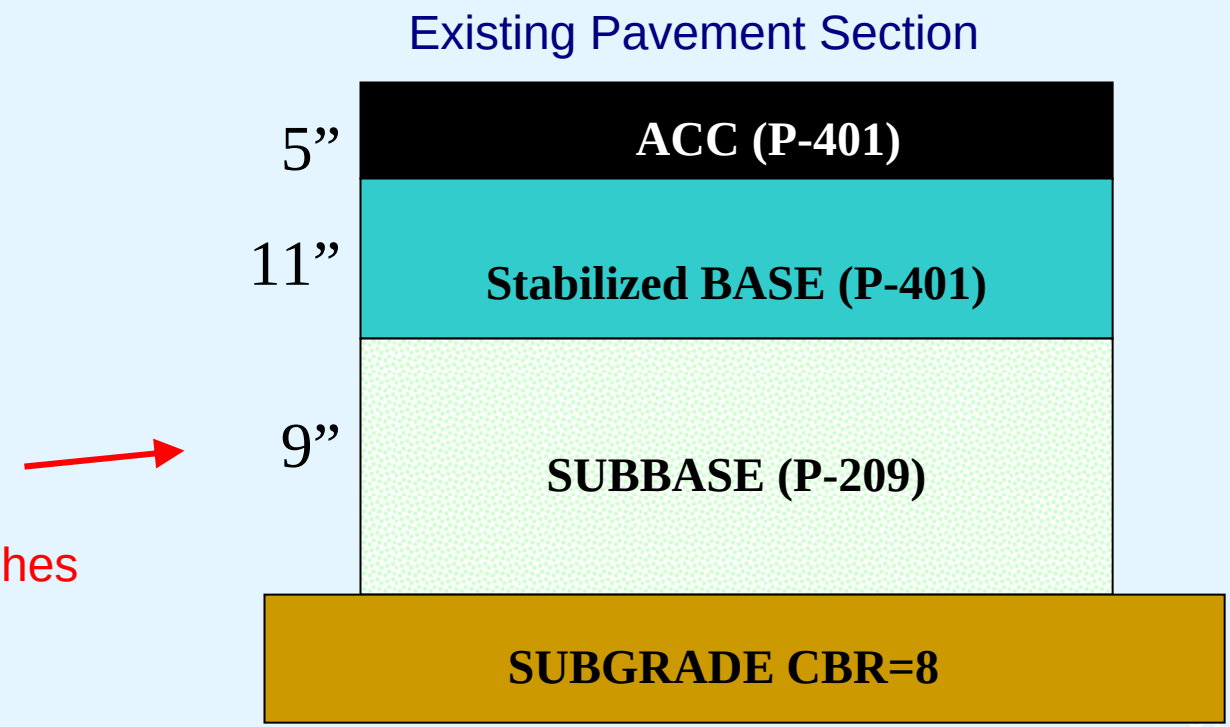
4 Basic Overlay Structures in FAARFIELD

Section Name	Pavement Type
AConFlex	Asphalt overlay on Flexible pavement
AConRigid	Asphalt overlay on Rigid pavement
PCConFlex	PCC overlay on flexible
PCConRigid	Unbonded PCC on rigid

FAARFIELD - Sample HMA Overlay Design

Assume the previous design example except that the existing structure is ~10 inches deficient in the subbase layer.

AConflex
Asphalt on existing flexible pavement

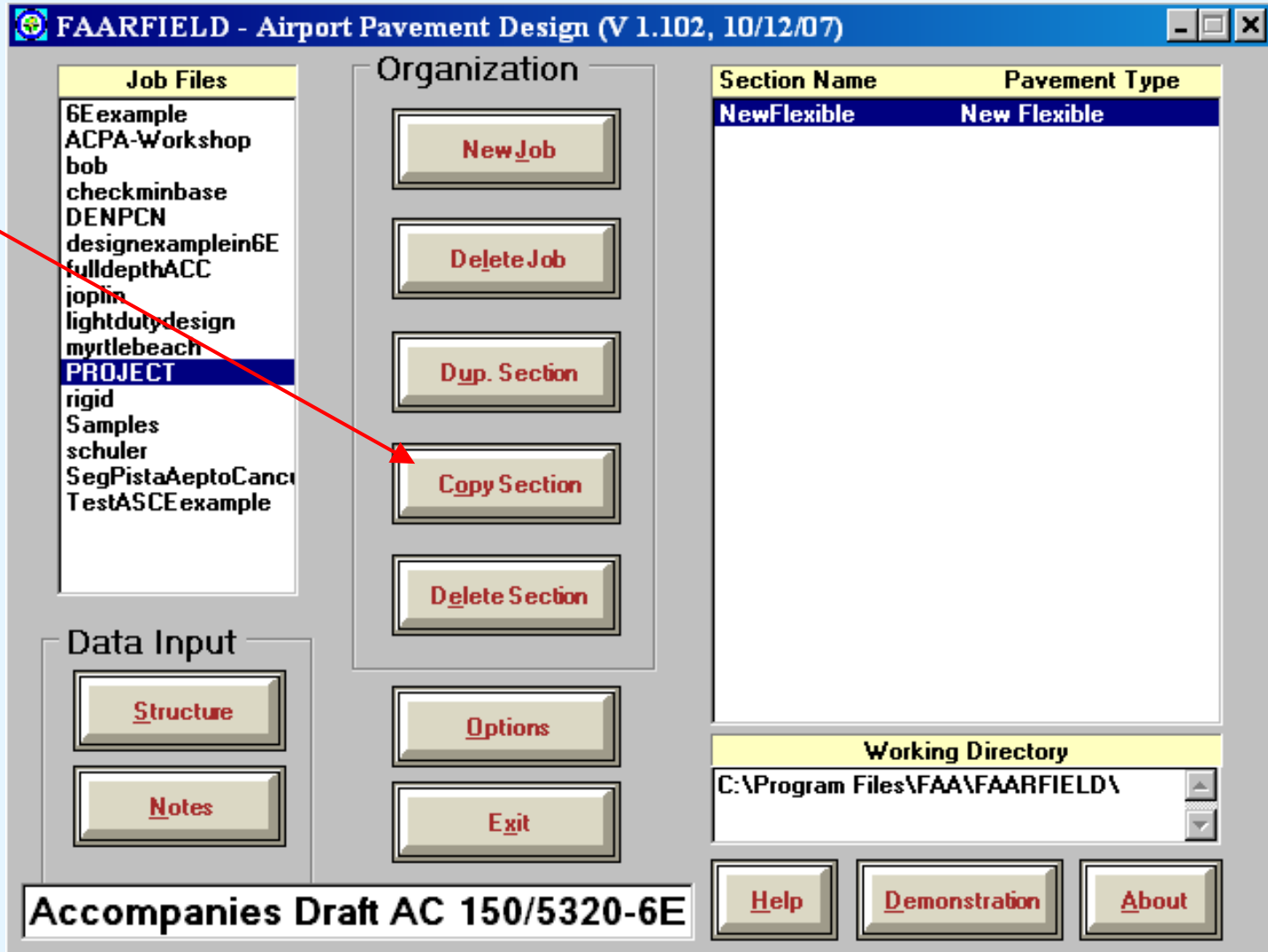


Original design required 18.8 inches of P-209

FAARFIELD - Sample HMA Overlay Design

Create Existing Pavement Section for Overlay Design

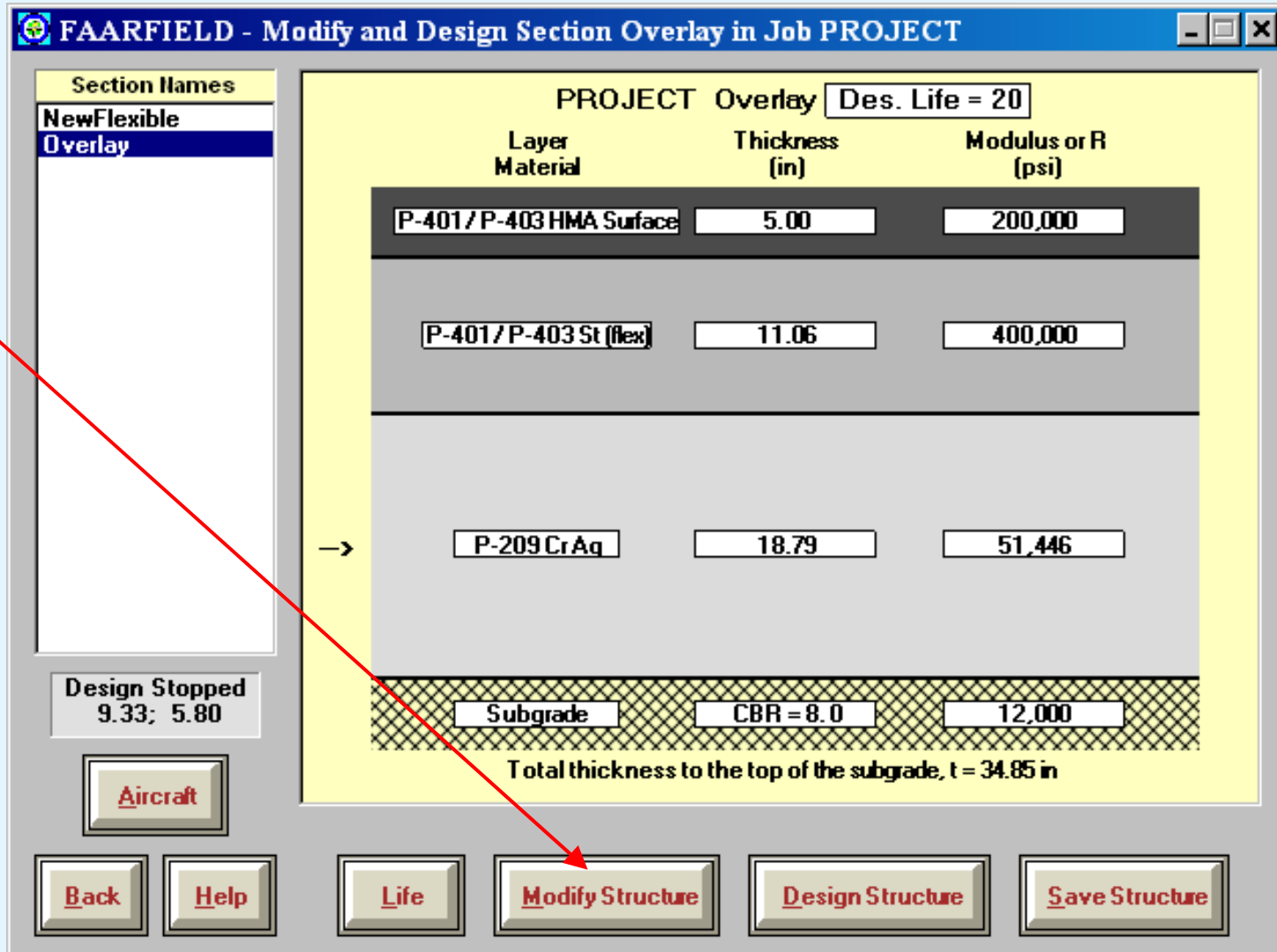
Copy the original pavement section – go to "Modify Structure"



FAARFIELD - Sample HMA Overlay Design

Create Existing Pavement Section for Overlay Design

Start with the original pavement section – go to "Modify Structure"

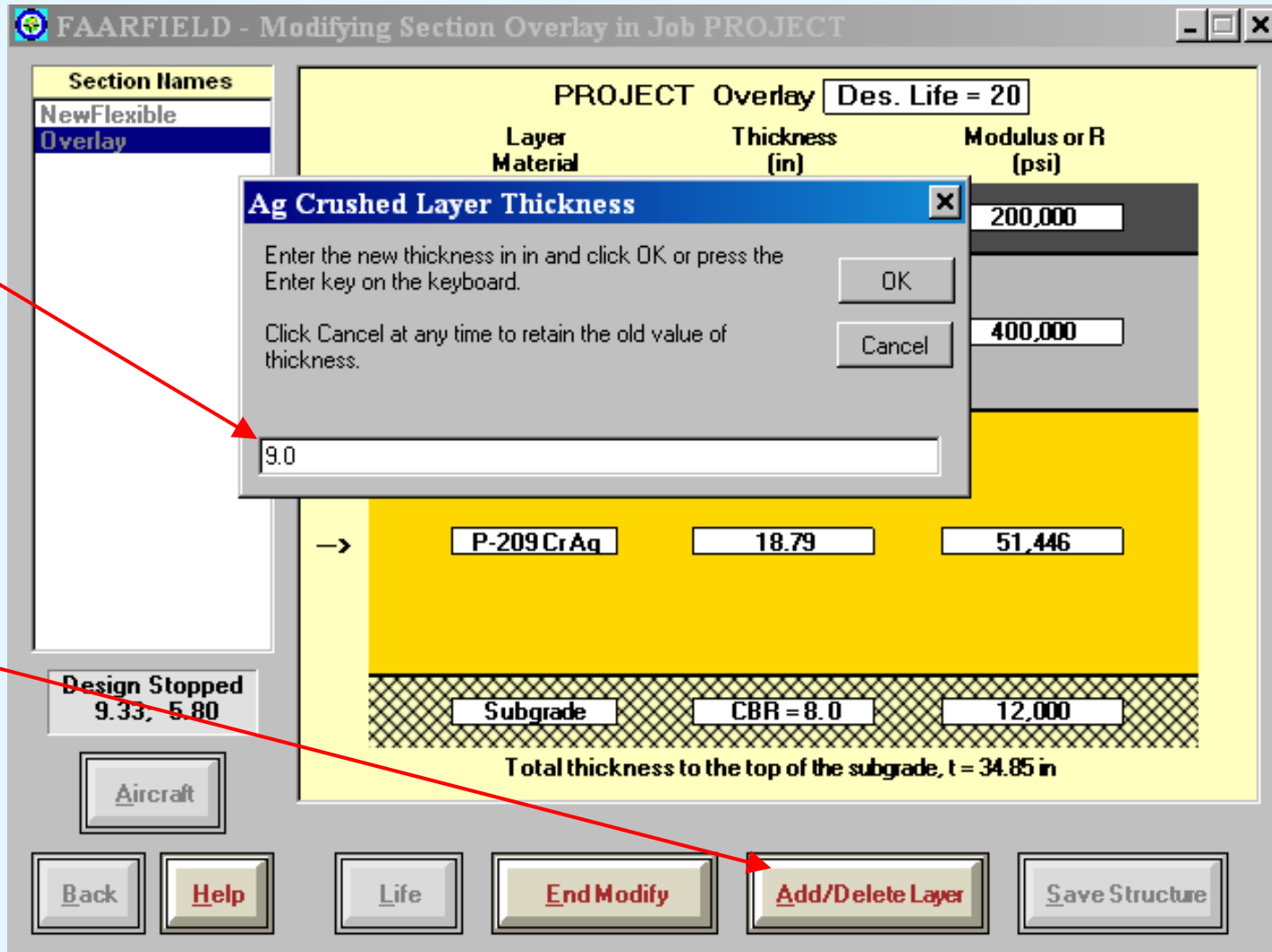


FAARFIELD - Sample HMA Overlay Design

Create Existing Pavement Section for Overlay Design

Click on the subbase thickness and enter 9.0 to establish the existing pavement structure

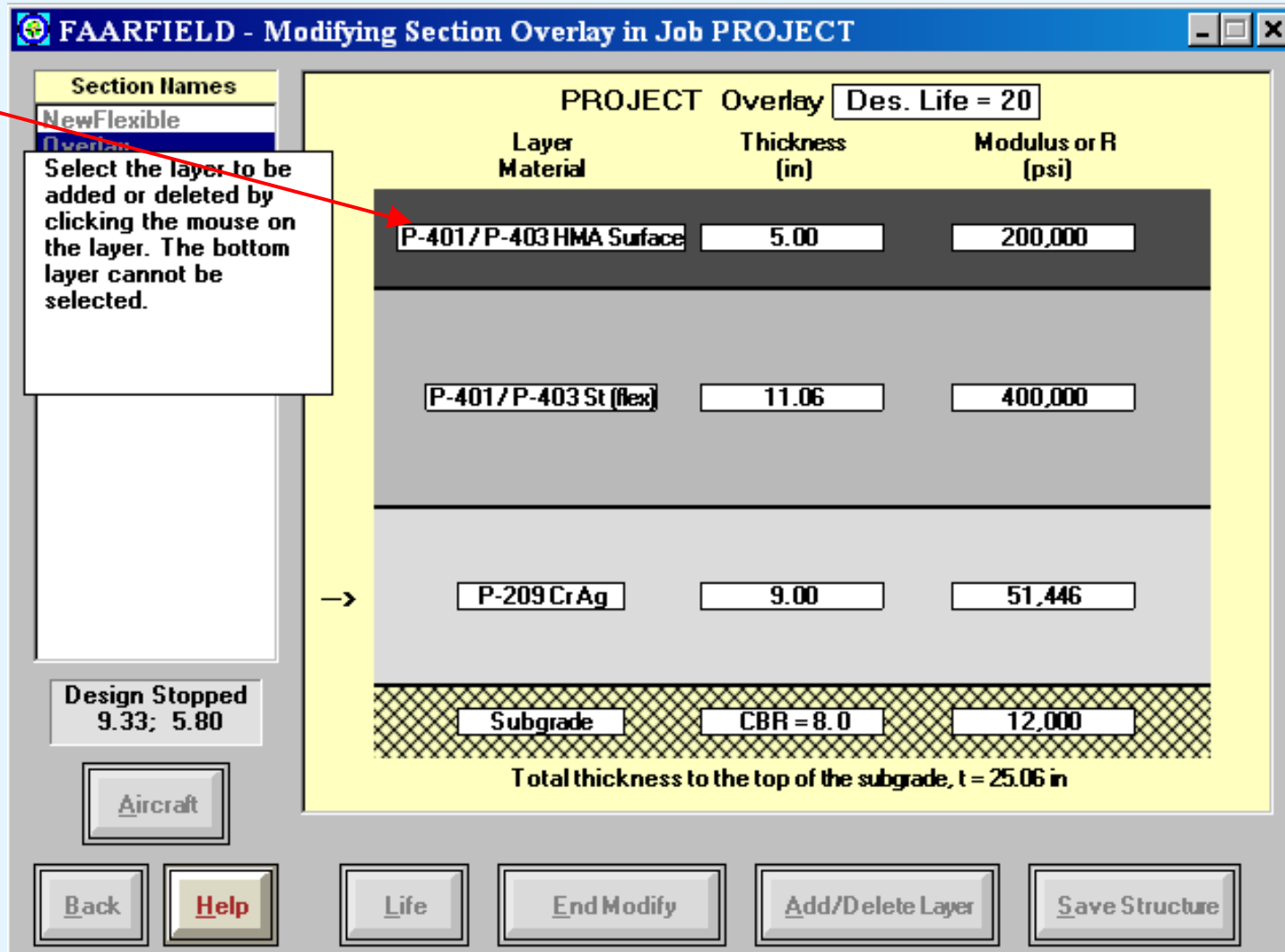
Then click on "Add/Delete Layer"



FAARFIELD - Sample HMA Overlay Design

Create Overlay Layer

Click on the P401 surface layer to add a section layer

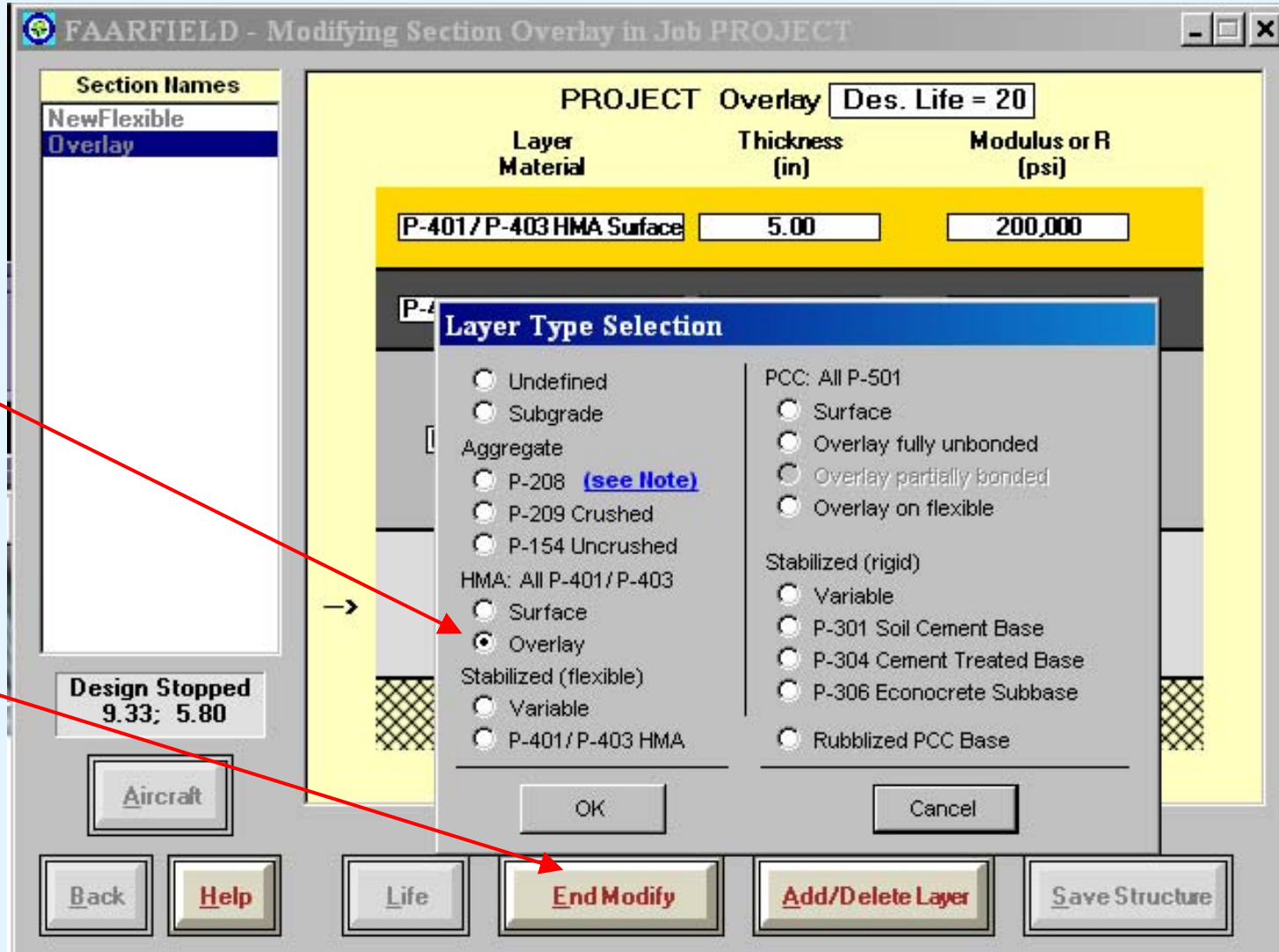


FAARFIELD - Sample HMA Overlay Design

Create Overlay Layer

Click on the top layer and change its properties to Asphalt P-401 Overlay

Then click on “End Modify” to return to design mode



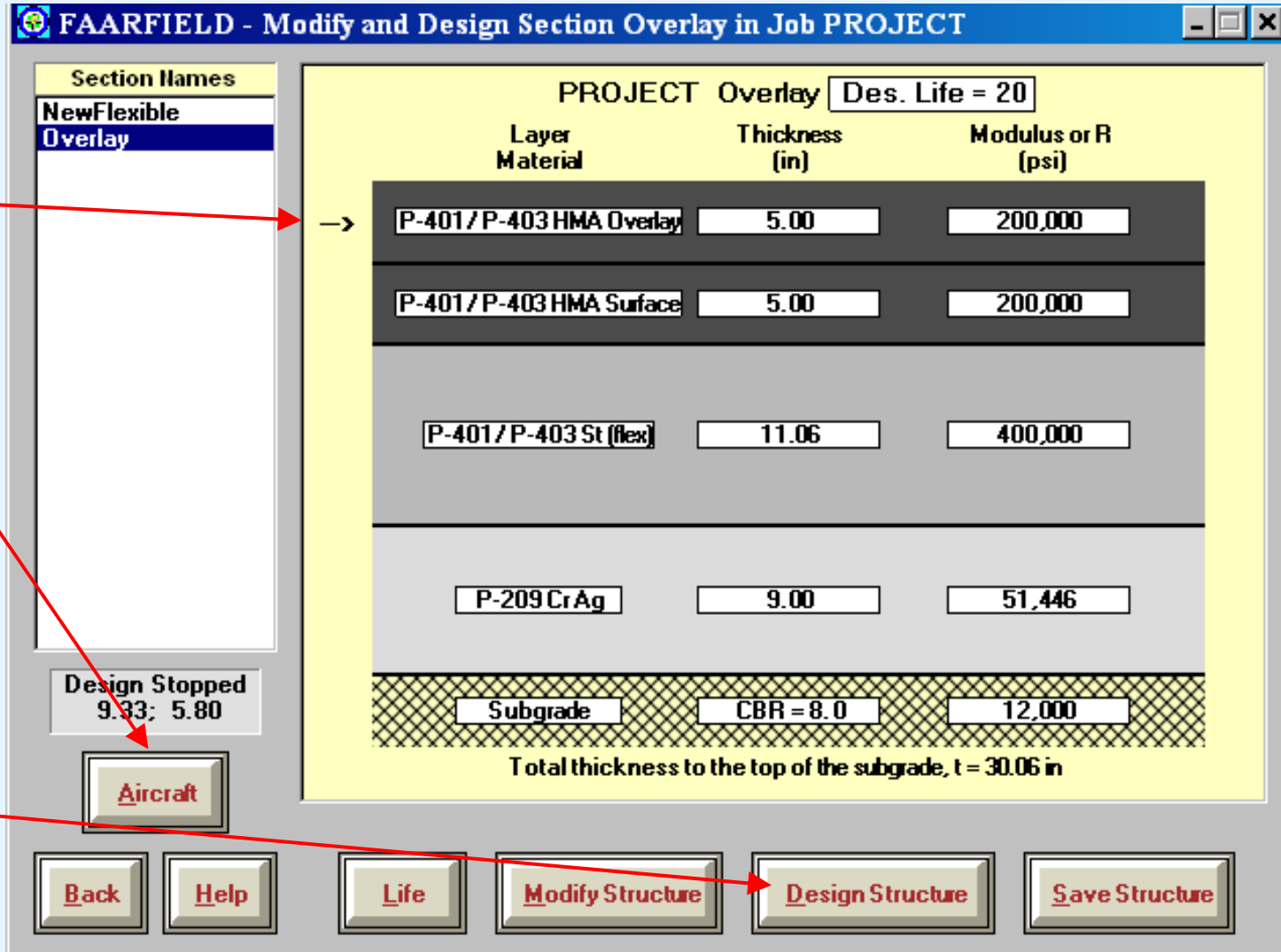
FAARFIELD - Sample HMA Overlay Design

Create Overlay Layer

Notice the arrow has relocated to the overlay layer

You may confirm or modify the airplane information

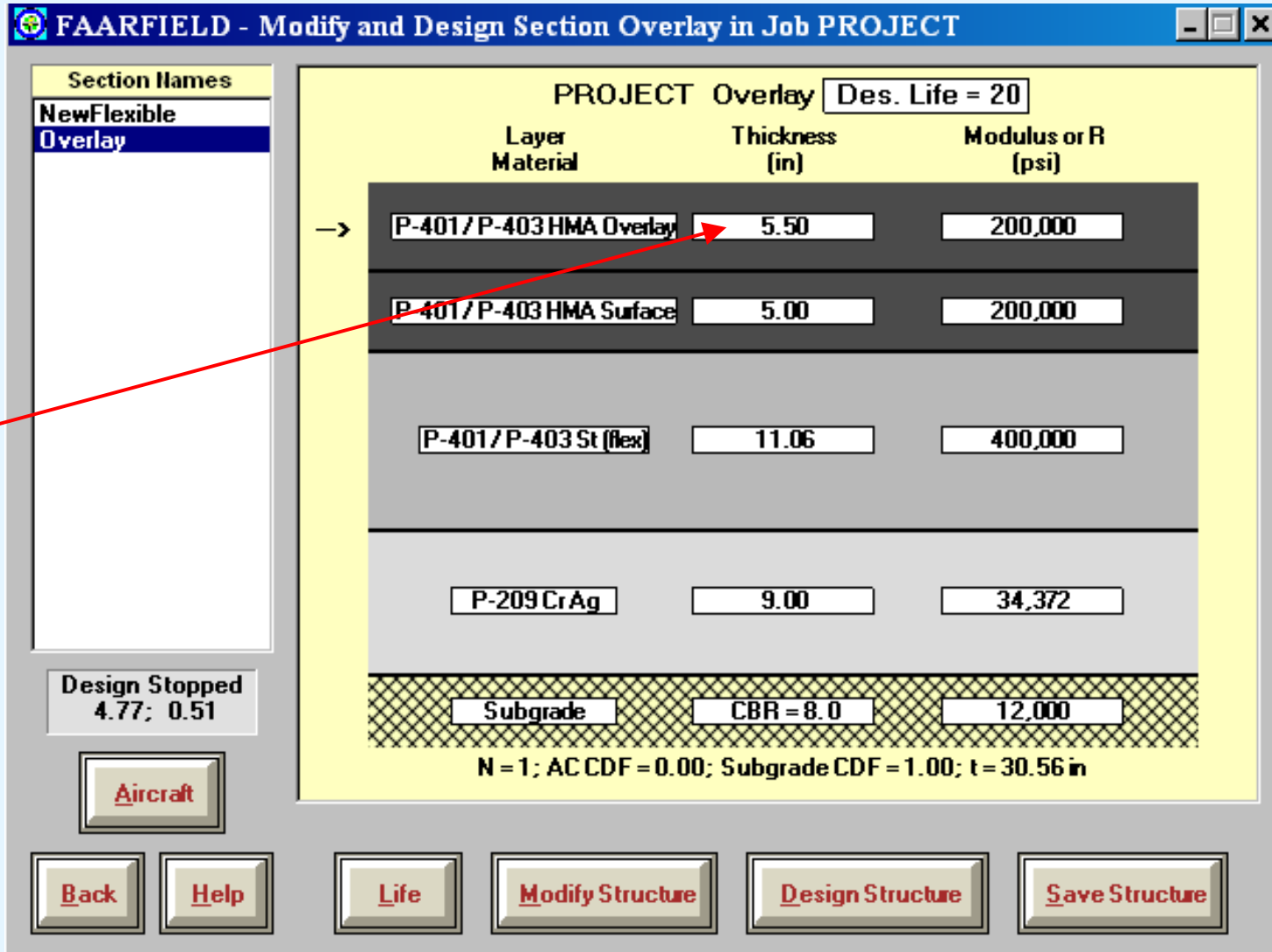
Then click “Design Structure” to complete the design



FAARFIELD - Sample HMA Overlay Design

Create Overlay Layer

The final overlay thickness is 5.5 inches



FAARFIELD - Sample HMA Overlay Design

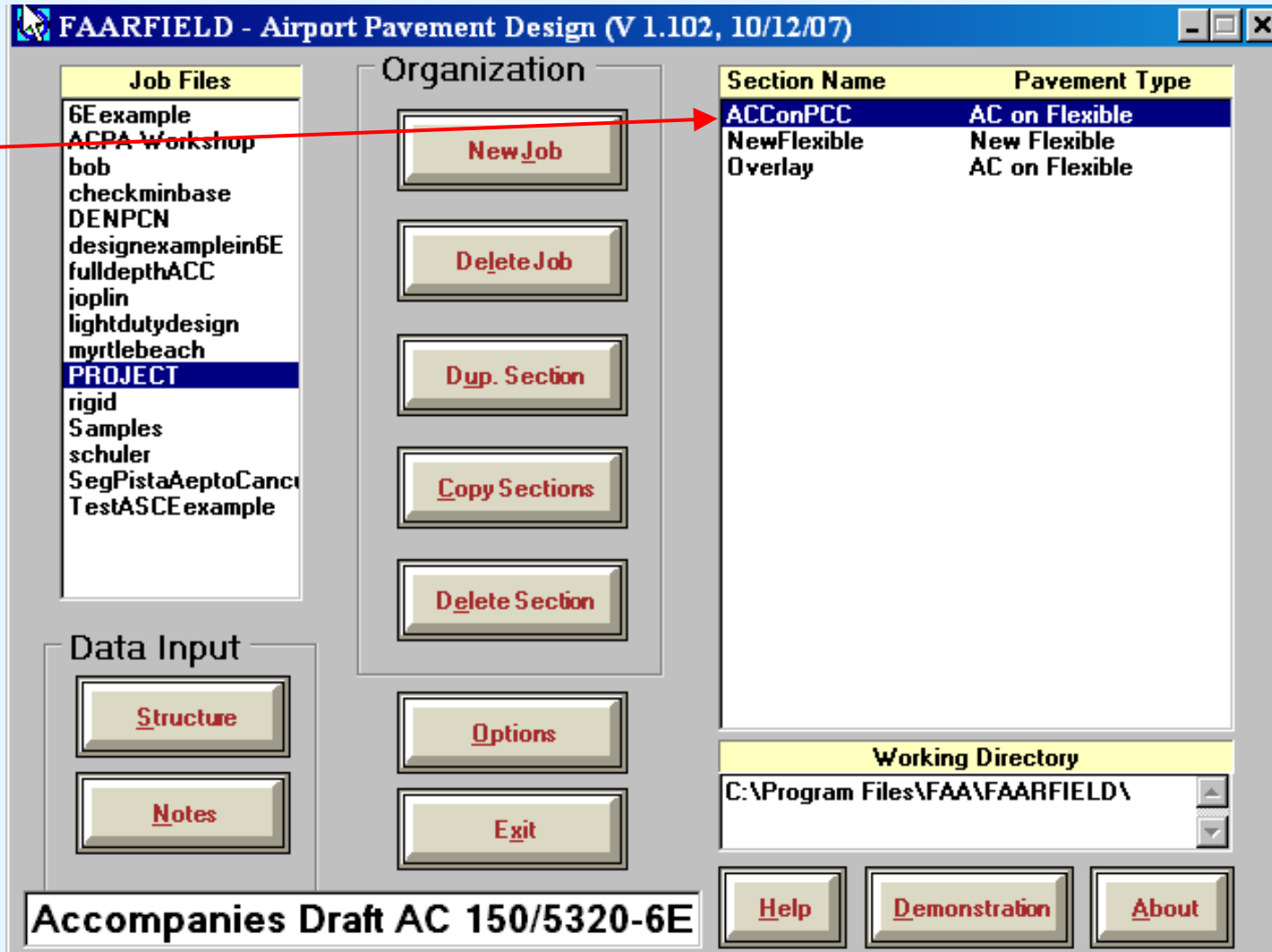
Overlay Design

Asphalt over Rigid Pavement

FAARFIELD - Sample HMA Overlay Design

Asphalt Over Rigid Pavement – Overlay Design

Create a new Section using the default samples or copying existing sections.

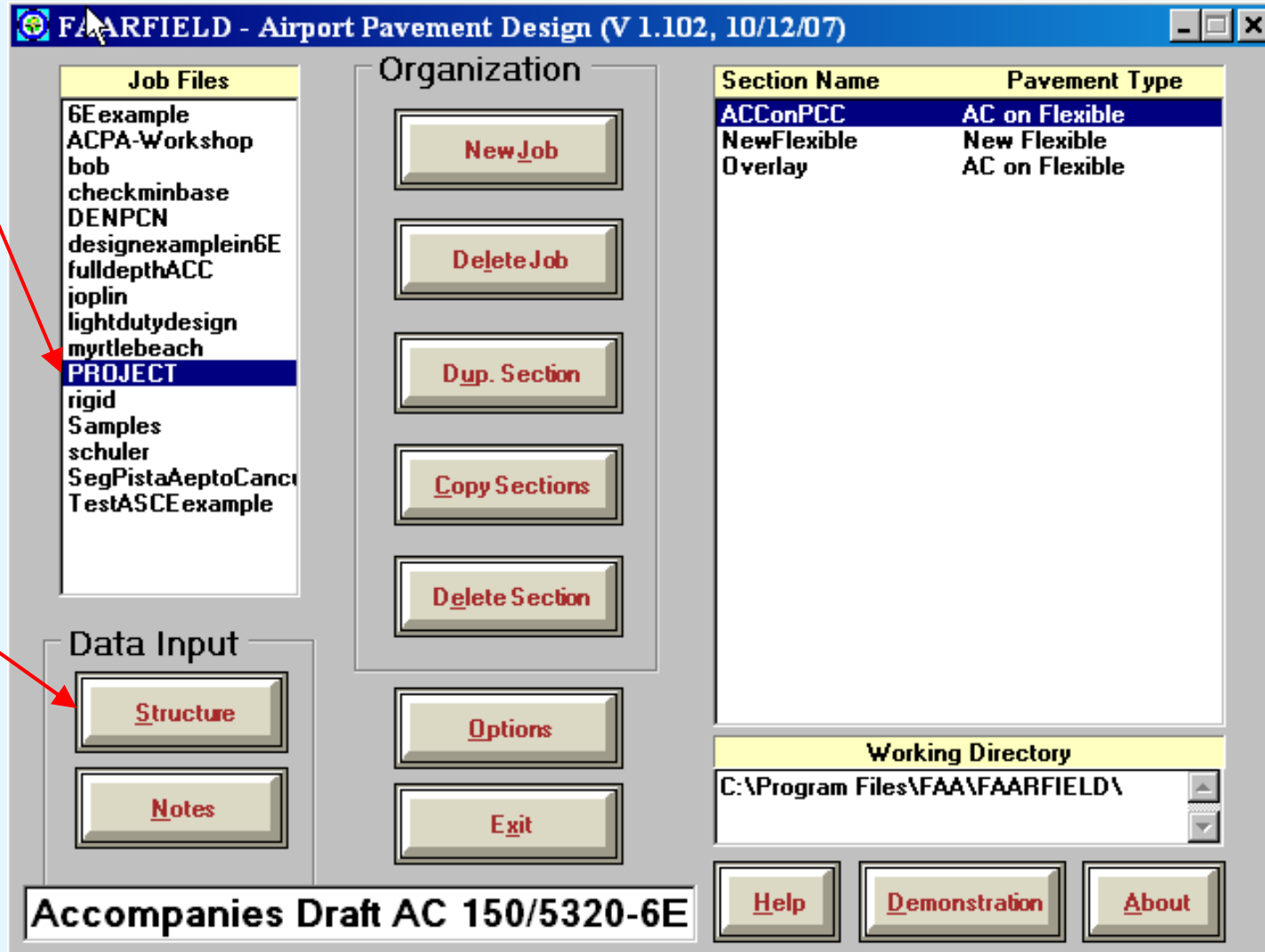


FAARFIELD - Sample HMA Overlay Design

Asphalt Over Rigid Pavement – Overlay Design

Select the Job file

Then open the structure

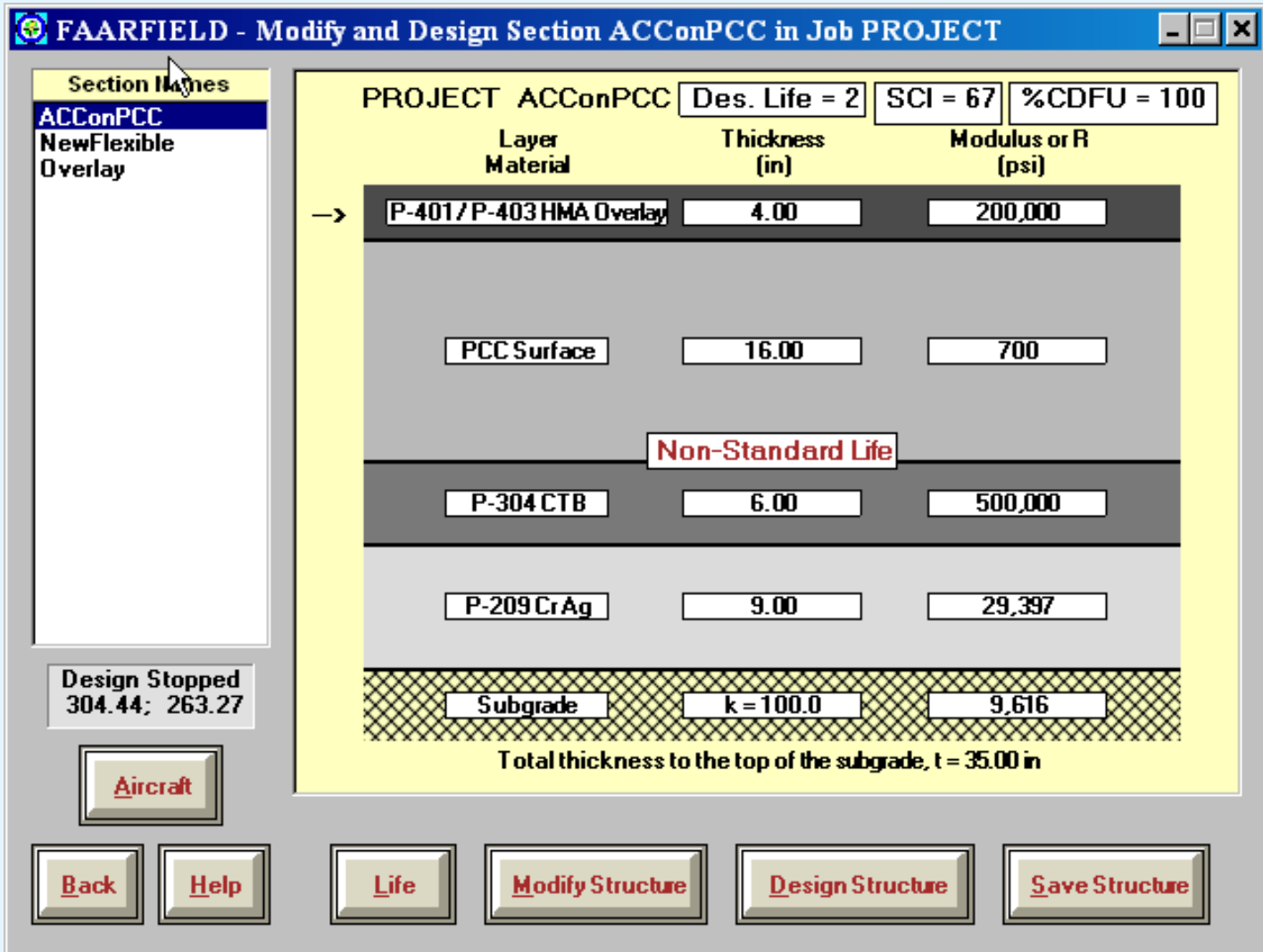


FAARFIELD - Sample HMA Overlay Design

Asphalt Over Rigid Pavement – Overlay Design

The new section may not automatically include the traffic mixture used for other sections.

You can copy the entire traffic mixture from a previous section to save time and effort.

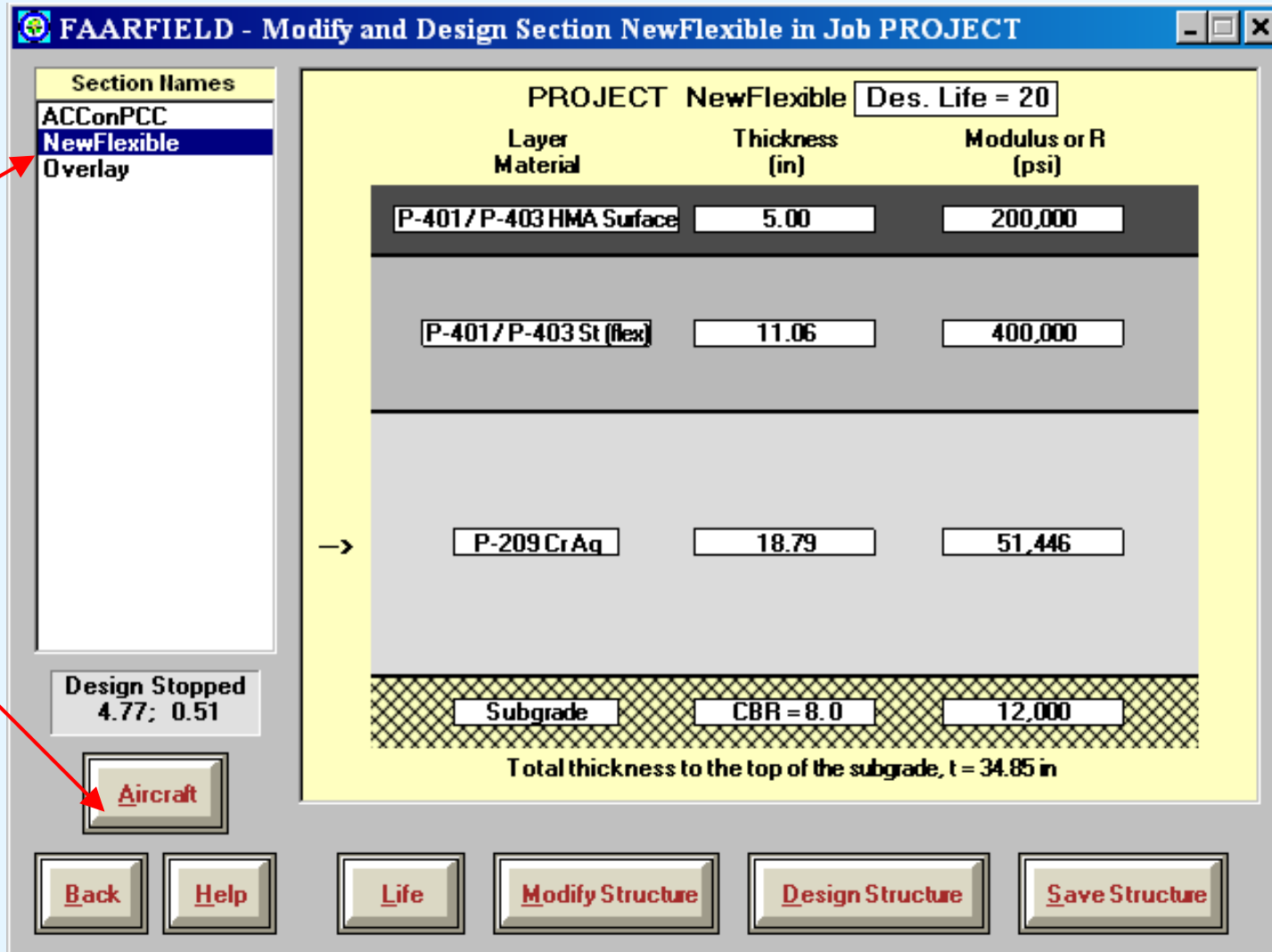


FAARFIELD - Sample HMA Overlay Design

Asphalt Over Rigid Pavement – Overlay Design

Select the section containing the traffic mixture you want to copy

Click “Aircraft”

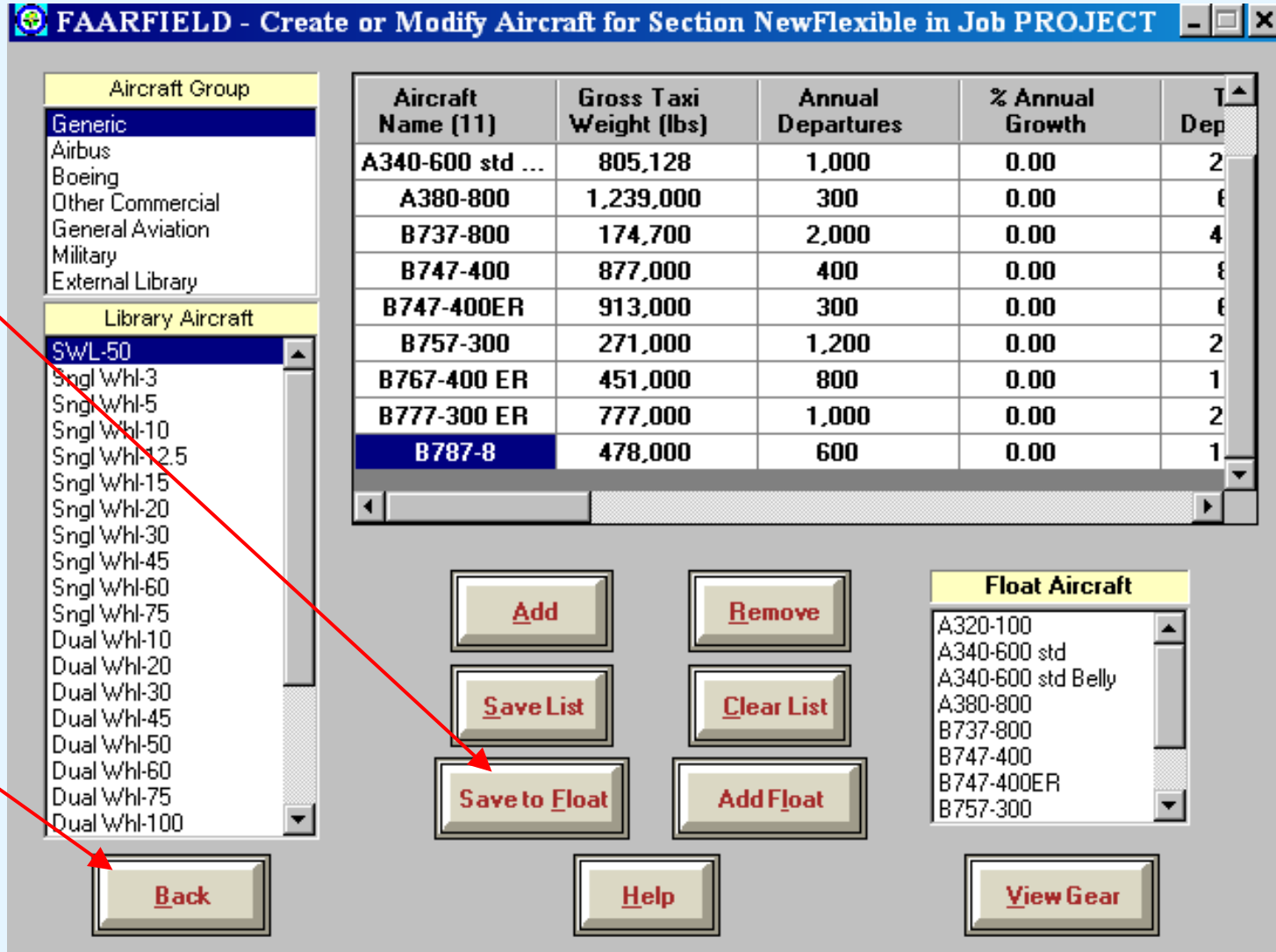


FAARFIELD - Sample HMA Overlay Design

Asphalt Over Rigid Pavement – Overlay Design

Click on “Save to Float” to copy the entire airplane list to the Float (like a clipboard)

Click “Back”

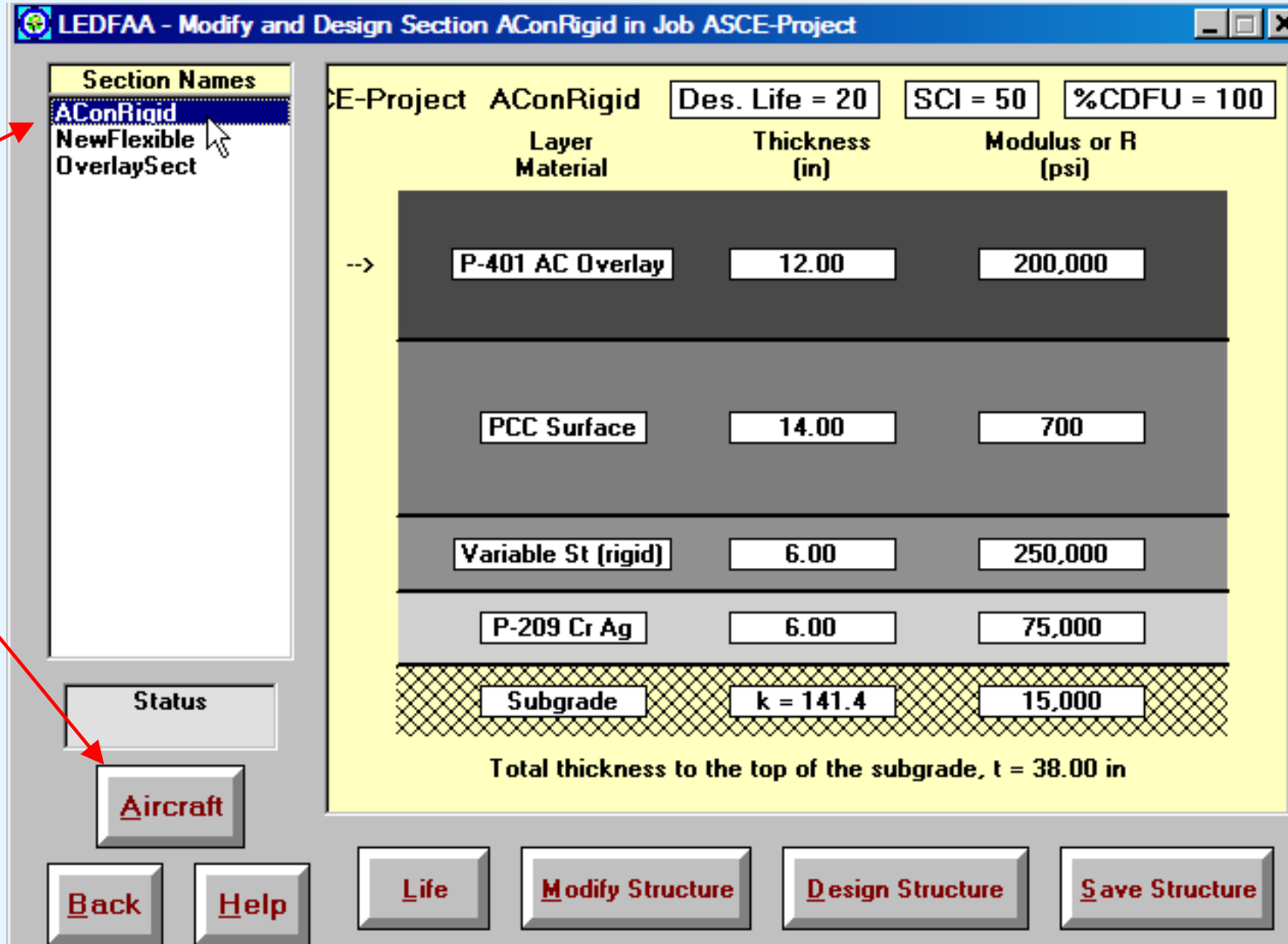


FAARFIELD - Sample HMA Overlay Design

Asphalt Over Rigid Pavement – Overlay Design

Select the new overlay section

Then click "Aircraft"

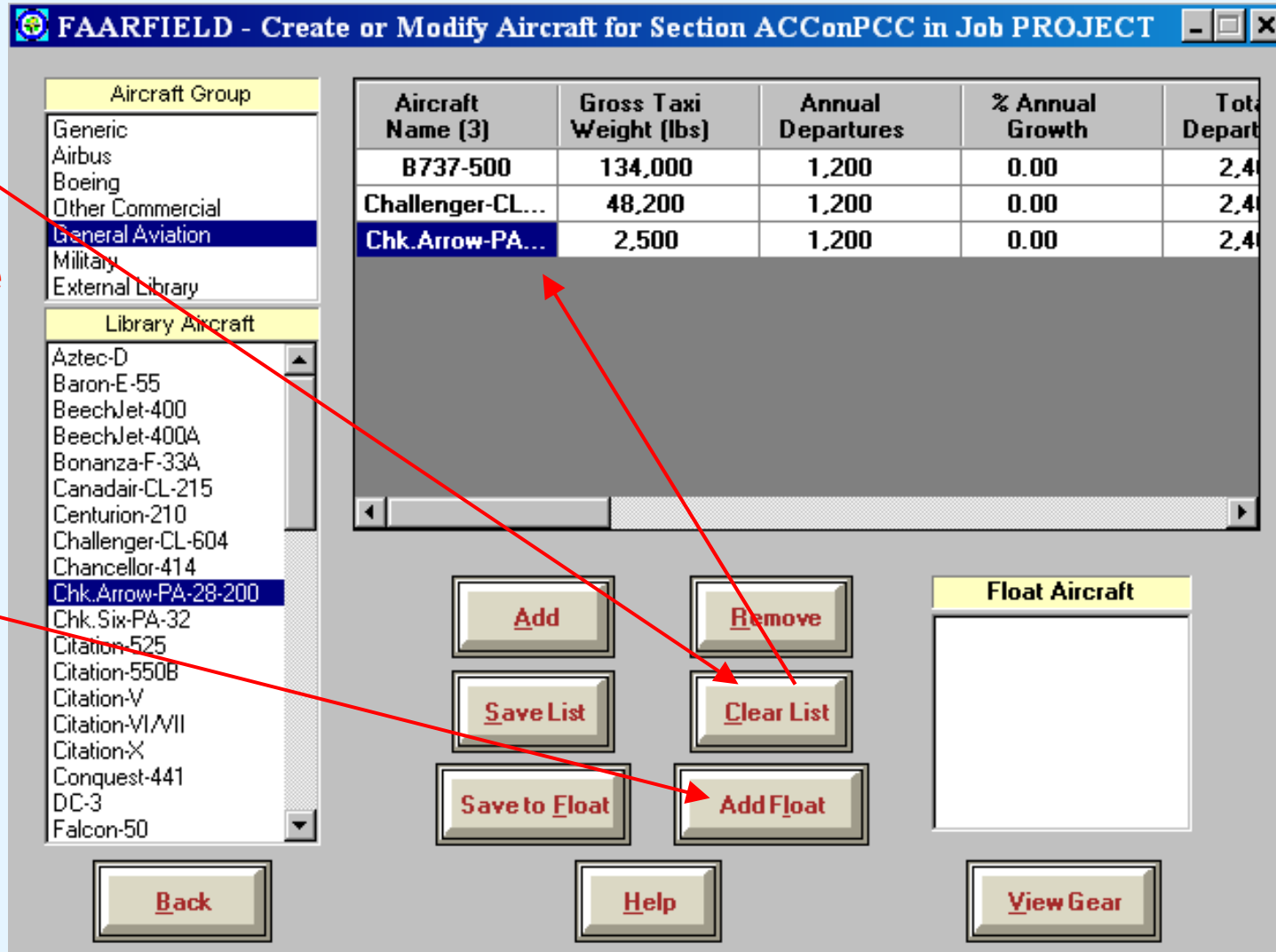


FAARFIELD - Sample HMA Overlay Design

Asphalt Over Rigid Pavement – Overlay Design

Click on "Clear List" to remove any existing airplanes from the section.

Then click on "Add Float" to add the Float list to the section

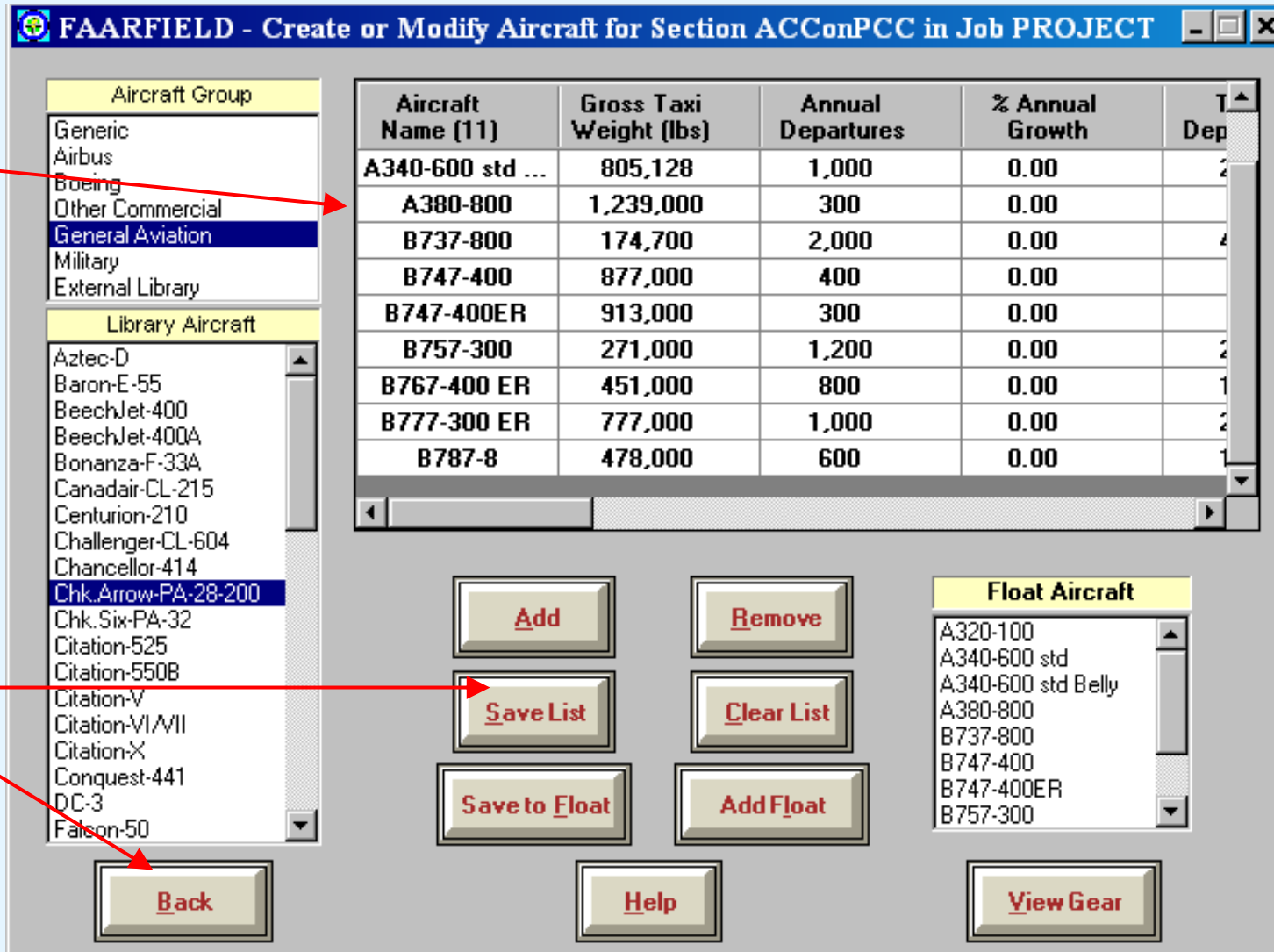


FAARFIELD - Sample HMA Overlay Design

Asphalt Over Rigid Pavement – Overlay Design

The updated list is now visible. You can modify the list if necessary

Once you are satisfied with the airplane list click "Save List" and "Back"

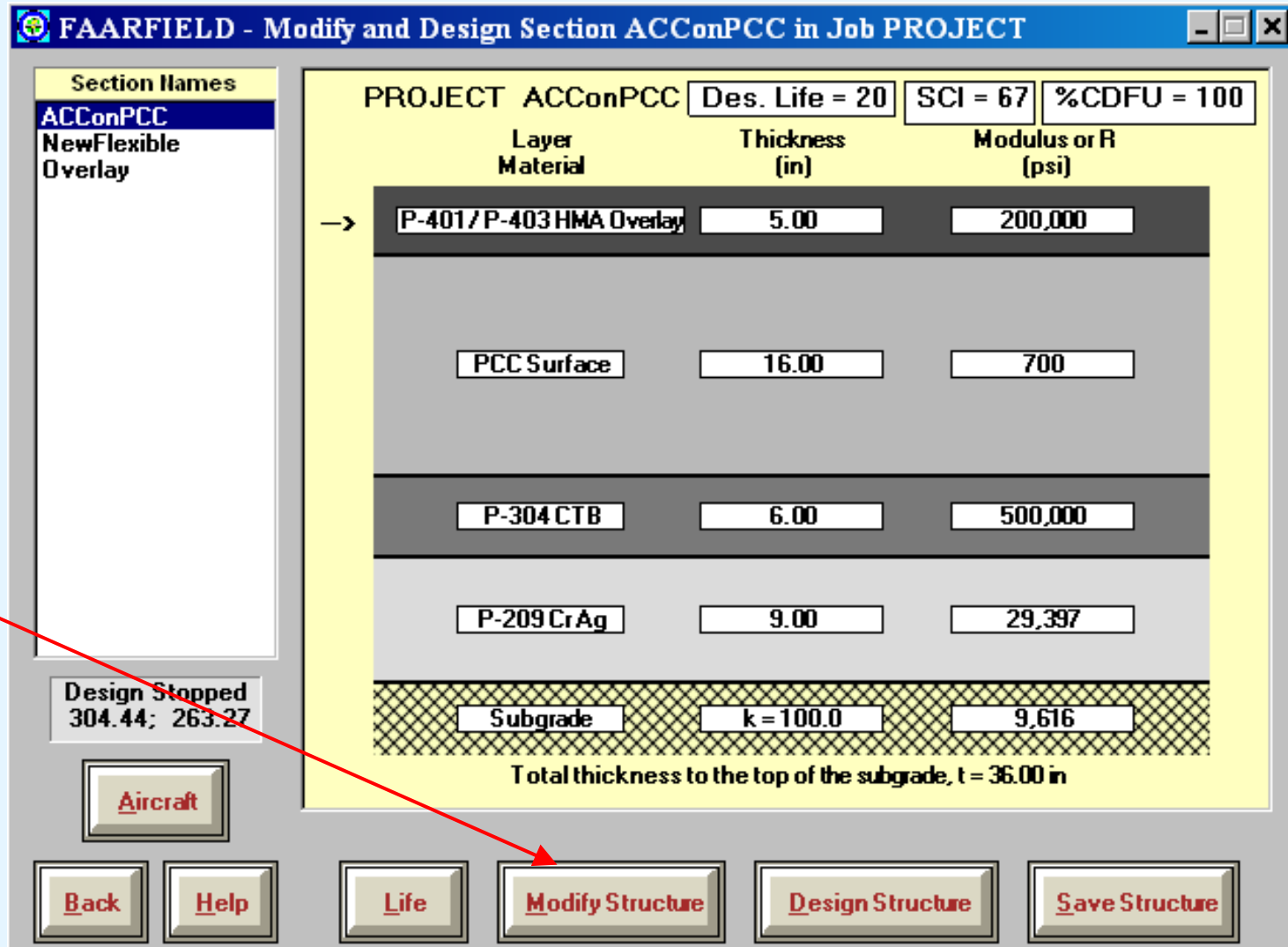


FAARFIELD - Sample HMA Overlay Design

Asphalt Over Rigid Pavement – Overlay Design

You may need to modify the sample section to accurately mimic your existing pavement section

Using the same procedures as before to modify the section



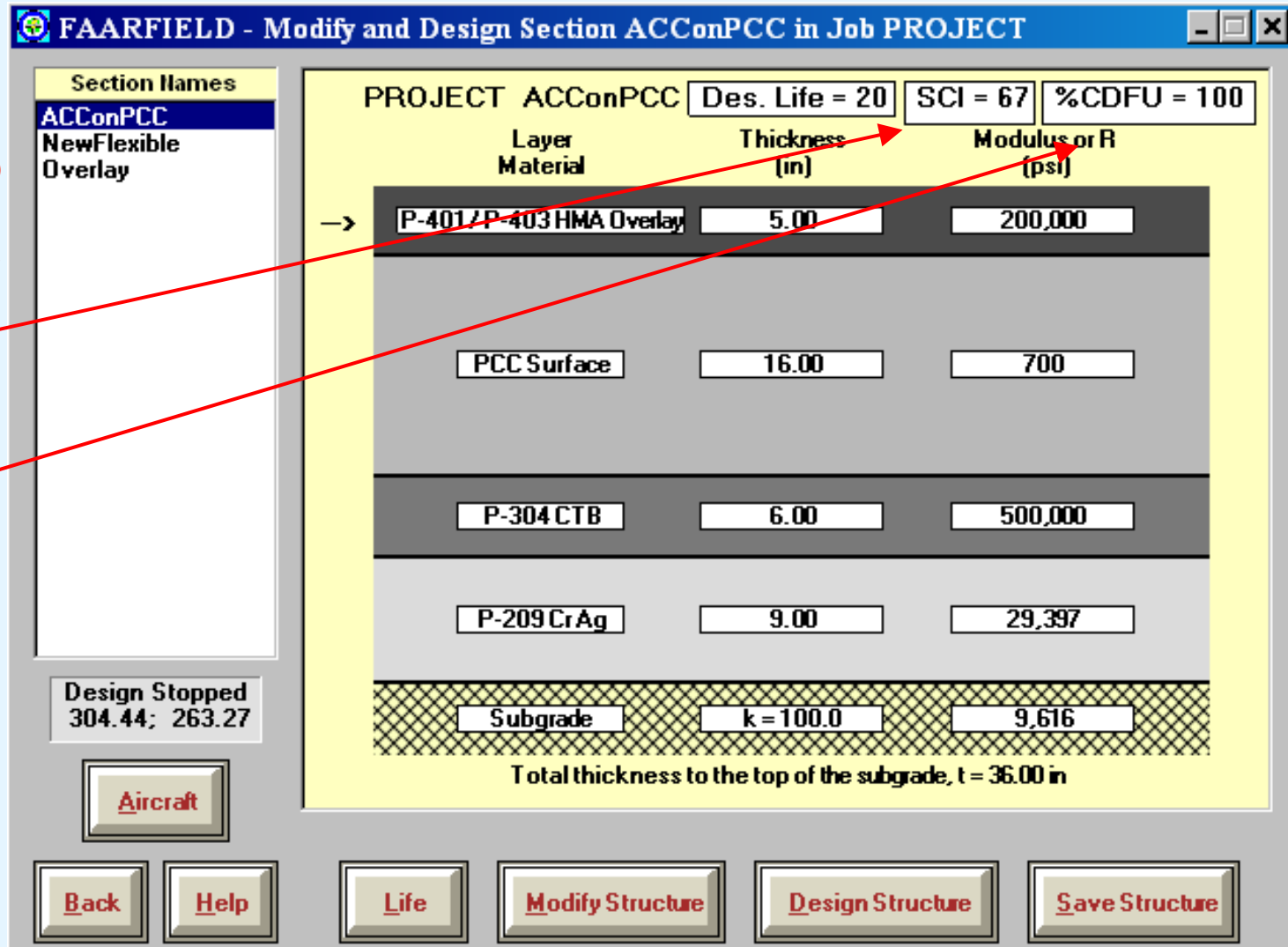
FAARFIELD - Sample HMA Overlay Design

Asphalt Over Rigid Pavement – Overlay Design

You will notice two new variables in the design window

SCI

%CDFU



FAARFIELD - Sample HMA Overlay Design

Asphalt Over Rigid Pavement – Overlay Design

SCI – Structural Condition Index

A measure of the structure condition of the existing pavement structure.

Summation of structural components from PCI Distress Survey

SCI range 0 (complete failure) – 100 (no distress)

FAARFIELD - Sample HMA Overlay Design

Asphalt Over Rigid Pavement – Overlay Design

CDFU = Cumulative Damage Factor Used

When SCI = 100, you must identify the percentage of pavement life that has already been consumed i.e. CDFU

$$CDFU = \frac{L_U}{0.75\,L_D} \quad \text{when } L_U < 0.75\,L_D$$

$$= \quad 1 \quad \text{when } L_U \geq 0.75\,L_D$$

LU = number of years of operation of the existing pavement until overlay

LD = design life of the existing pavement in years

To calculate CDFU – create original structure, create traffic applied to this point, use "Life" button

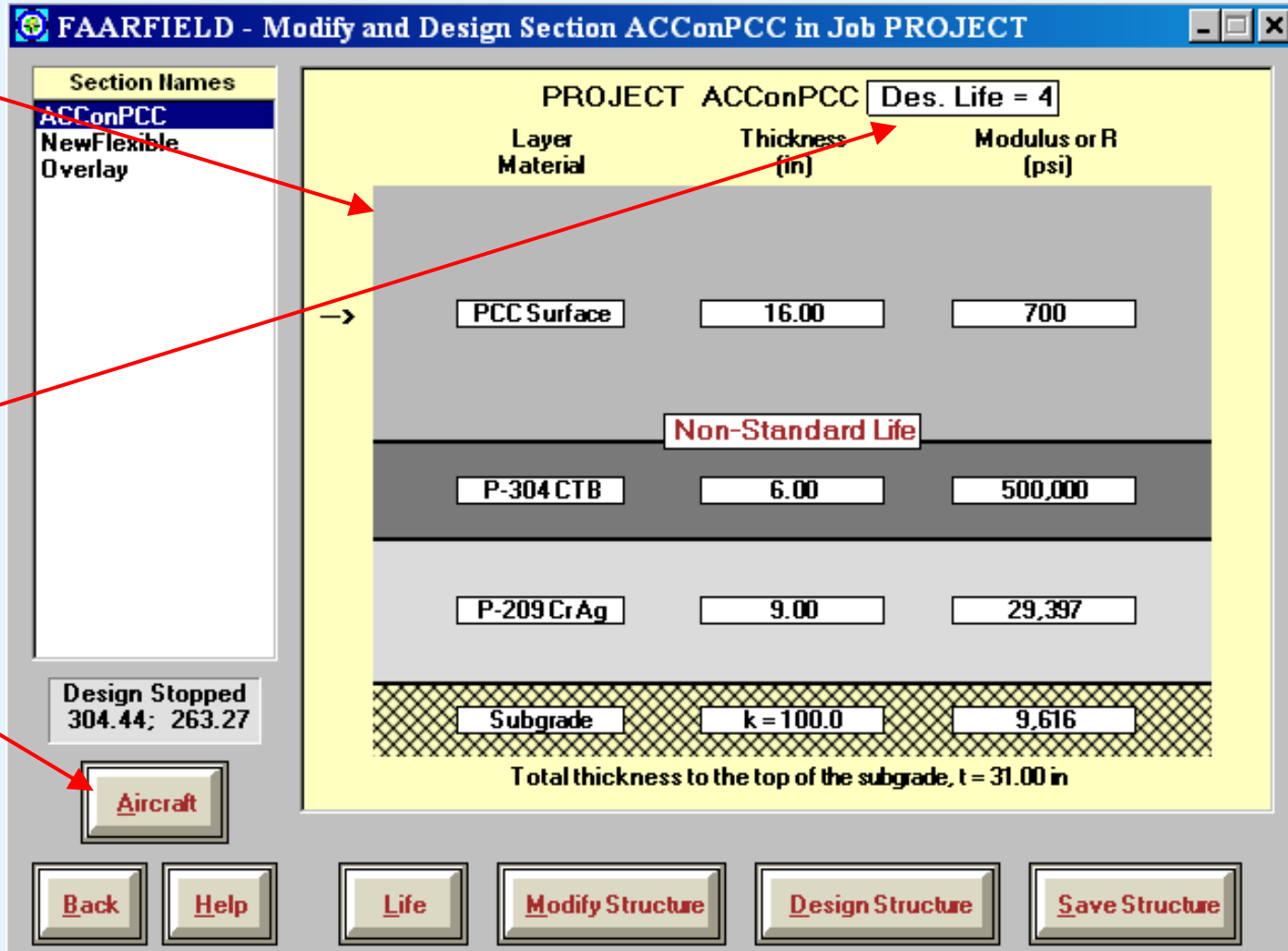
FAARFIELD - Sample HMA Overlay Design

Asphalt Over Rigid Pavement – Overlay Design Calculate CDFU

Overlay removed to create original structure

Design Life changed to 4 years to estimate in-service life.

Click on “Aircraft” to enter historic traffic mixture

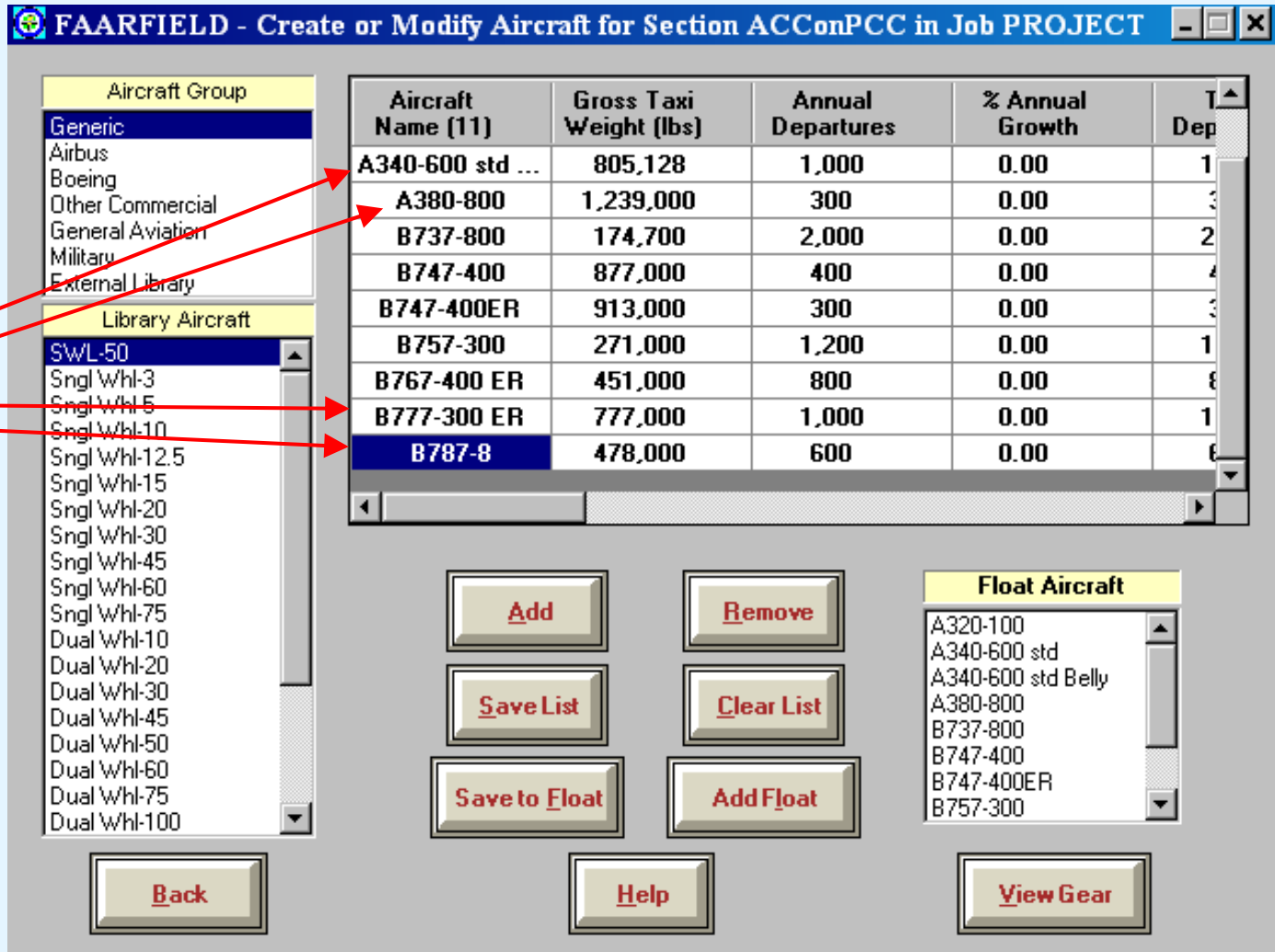


FAARFIELD - Sample HMA Overlay Design

Asphalt Over Rigid Pavement –

Overlay Design Calculate CDFU

For this example assume the B777, B787, A340 and A380 are not in the historic traffic mix, Remove these airplanes.

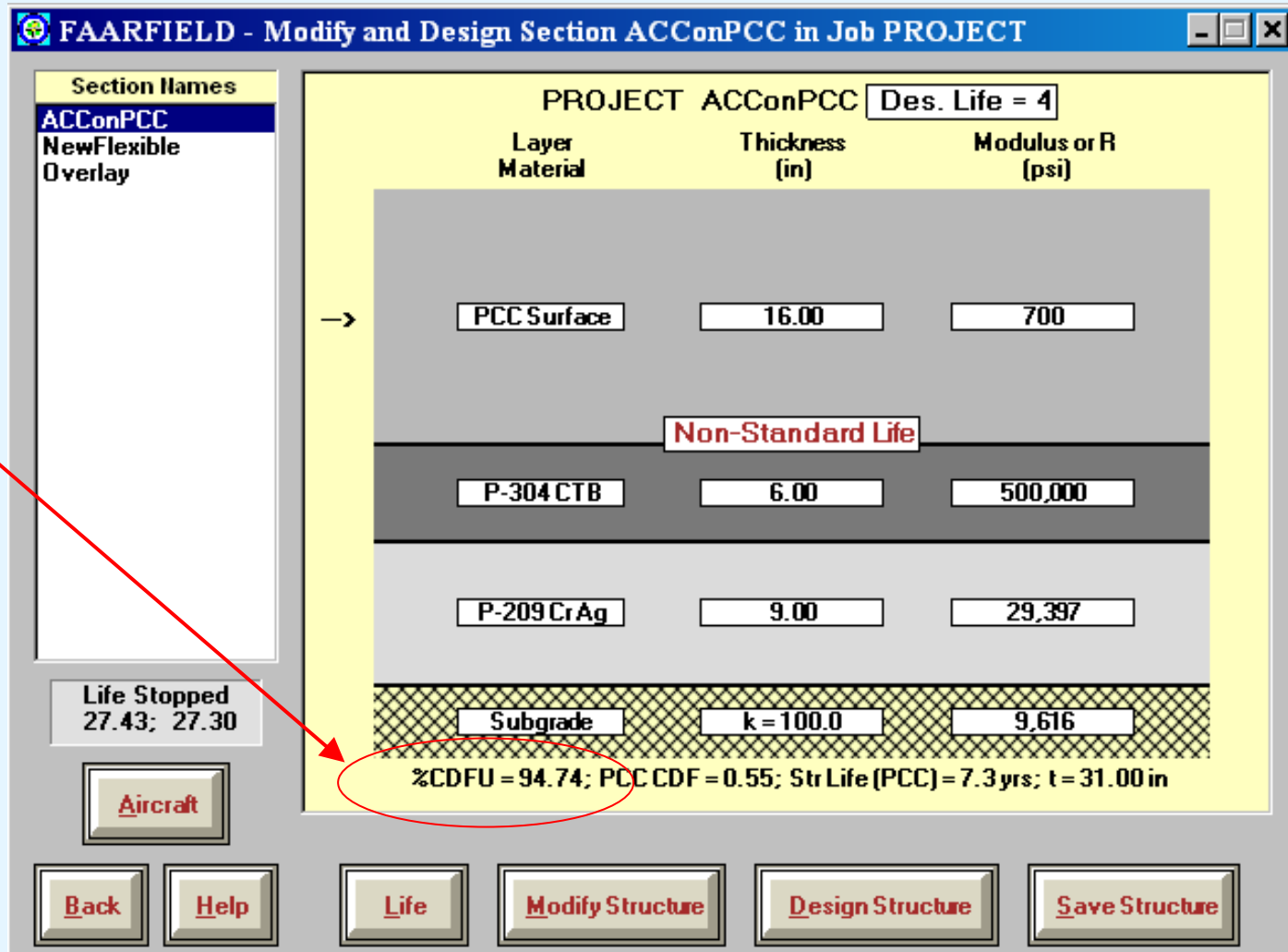


FAARFIELD - Sample HMA Overlay Design

Asphalt Over Rigid Pavement – Overlay Design Calculate CDFU

Click the “Life” button and the %CDFU for this pavement structure and the historic traffic will be displayed

%CDFU =94.7% indicates that the pavement life is mostly consumed. Enter this value for CDFU before design



FAARFIELD - Sample HMA Overlay Design

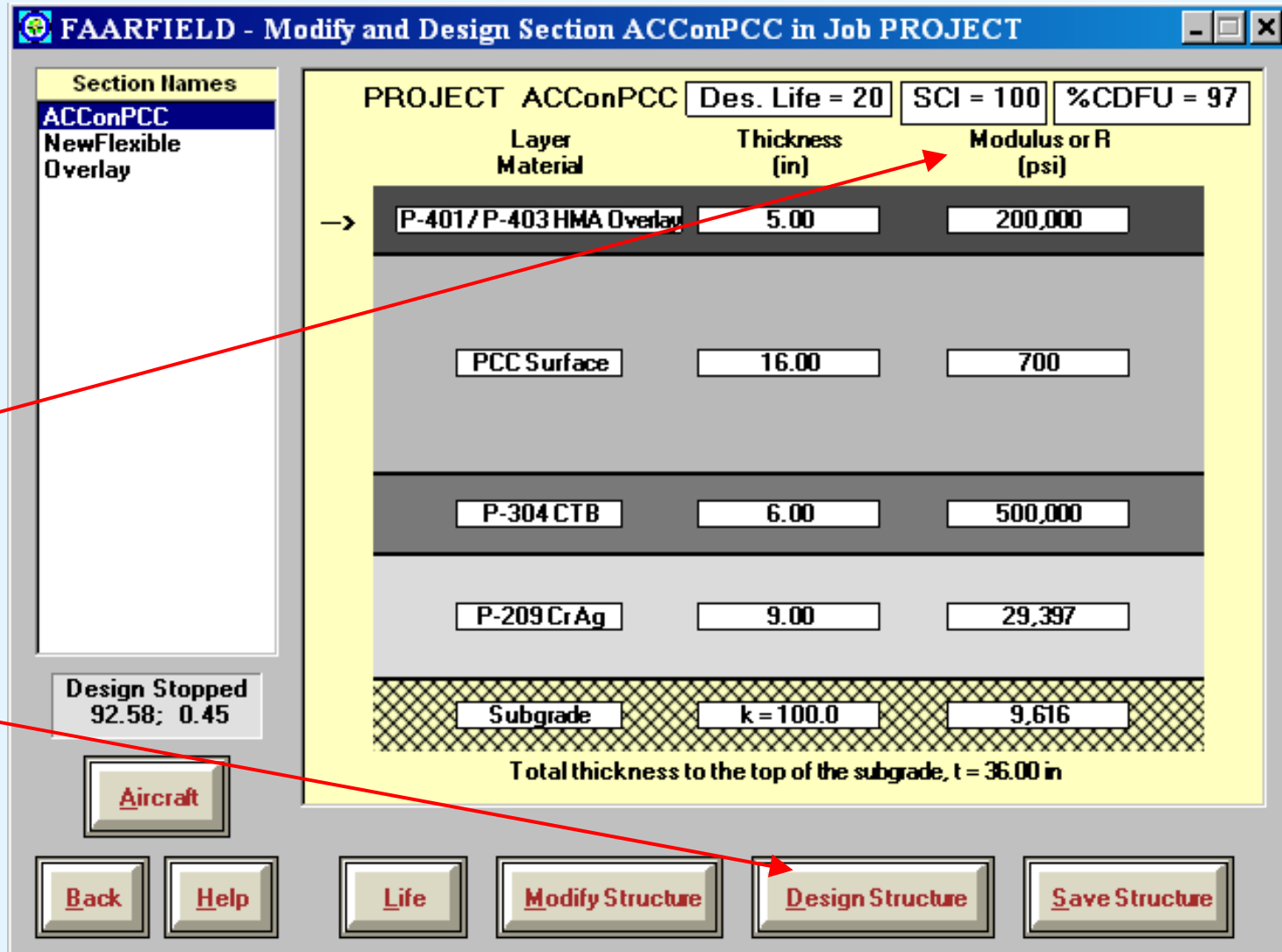
Asphalt Over Rigid Pavement – Overlay Design

Return to original overlay section

Restore original traffic mixture

Adjust SCI and %CDFU

Click on “Design Structure” to complete the overlay design

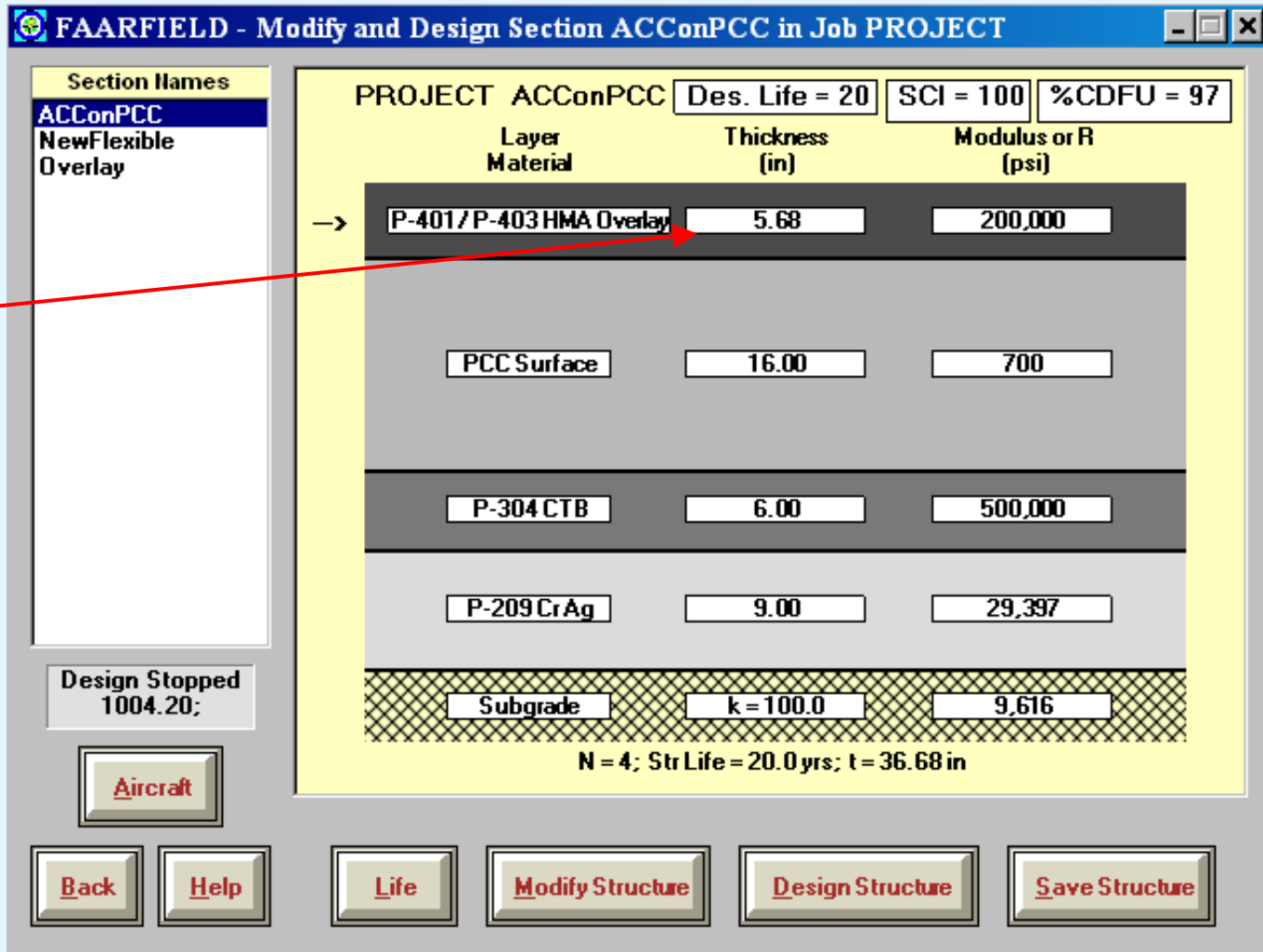


FAARFIELD - Sample HMA Overlay Design

Asphalt Over Rigid Pavement – Overlay Design

Final Pavement Section

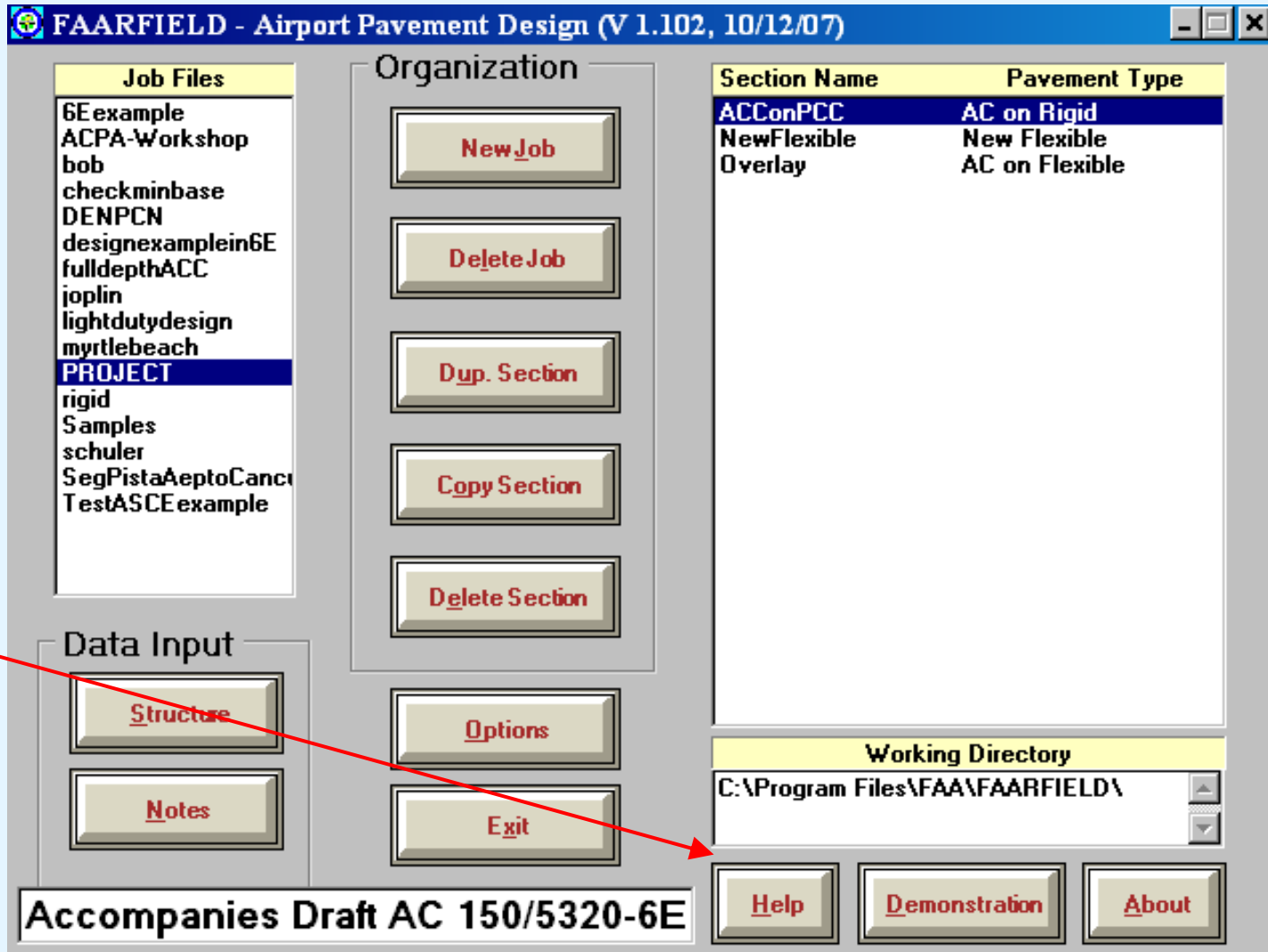
Requires ~6.0 inch overlay thickness



FAARFIELD - Help Manual

Interactive User's Manual / Help File

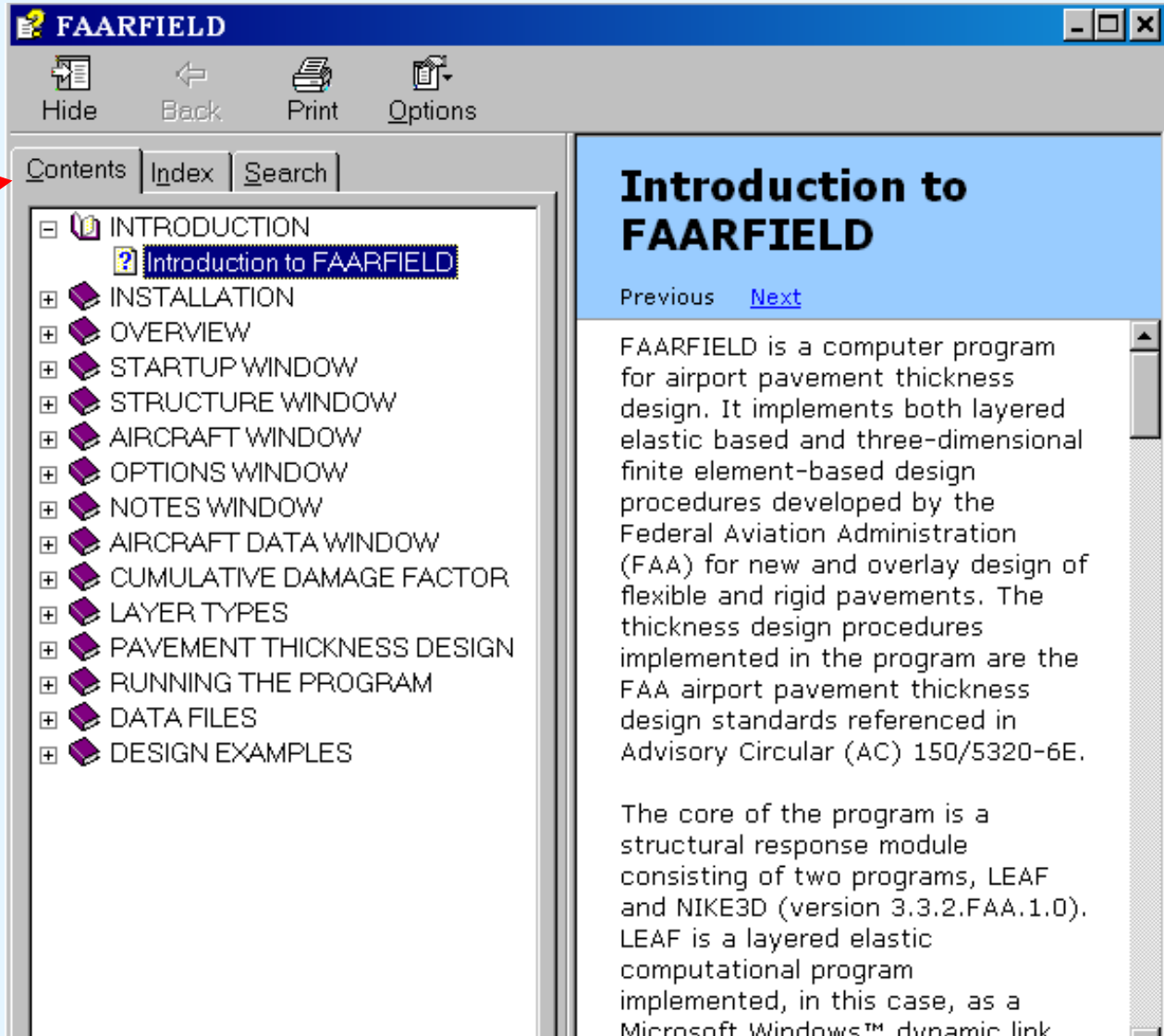
For assistance with the program click the Help key



FAARFIELD - Help Manual

Interactive User's Manual / Help File

Search by Contents/chapters, Index, or word search

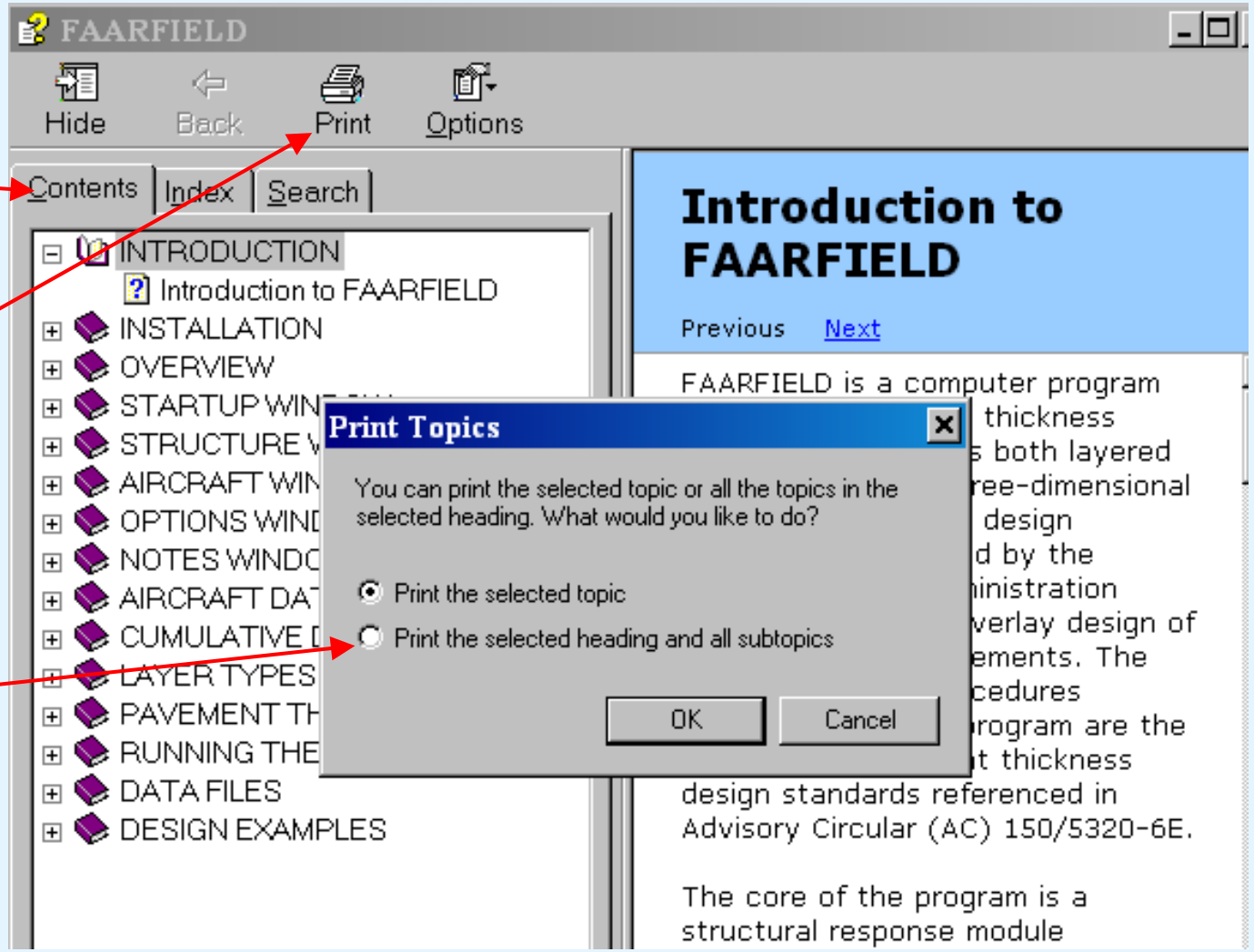


FAARFIELD - Help Manual

Printing Help Manuals

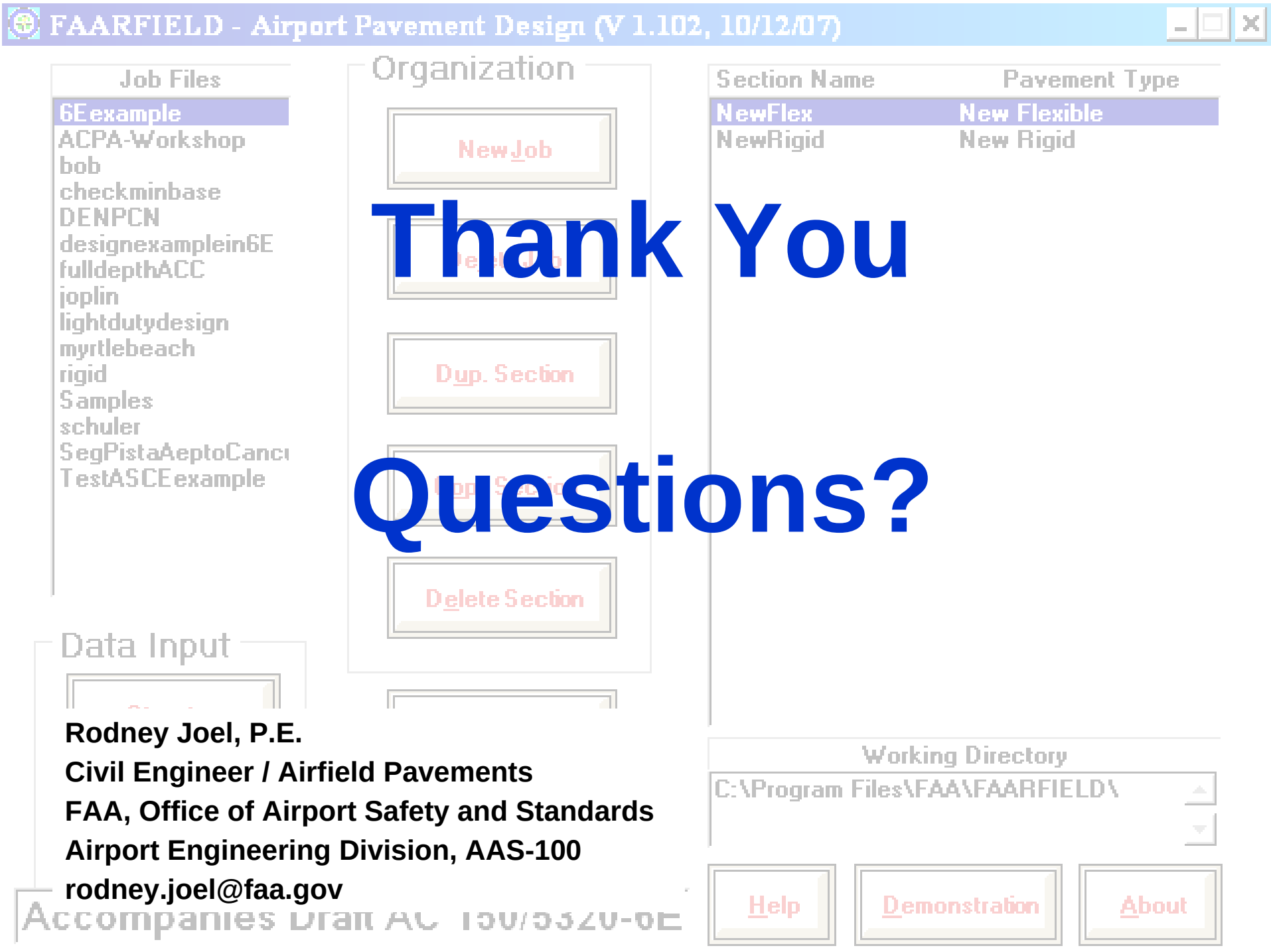
To print the manual move to the "Contents" tab and click Print

Select "Print the selected heading and all subtopic" Do this for each heading



Software Available at:

http://www.faa.gov/airports_airtraffic/airports/construction/design_software/



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